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Carrie L. Traver

Water Quality & Monitoring Programs Division
Susquehanna River Basin Commission

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**Statutory Citations: Federal - Pub. L. 91-575, 84 Stat. 1509 (December 1970); Maryland - Natural Resources Sec. 8-301 (Michie 1974); New York - ECL Sec. 21-1301 (McKinney 1973); and Pennsylvania - 32 P.S. 820.1 (Supp. 1976).*

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CONTENTS

ACKNOWLEDGEMENTS ix

ABSTRACT 1

INTRODUCTION 1

METHODS 5

Field and Laboratory Methods 5

Chemical water quality 5
Physical habitat and biological conditions 9

Data Analysis Methods 9

Reference category designation 9
Chemical water quality 9
Physical habitat and biological conditions 13

RESULTS 18

Reference Category 64ac 18
Reference Category 64d 18
Reference Category 64L 18
Reference Category 66 18
Reference Category 67a 18
Reference Category 67b 40
Reference Category 67cd 40
Reference Category 67L 40
Susquehanna River Sites 64

BIOASSESSMENT OF STREAMS AND RIVERS 71

Northern Section Streams 71

Shamokin Creek 71
Penns Creek Watershed 72
Mahanoy Creek 73
West Mahantango Creek 73
East Mahantango Creek Watershed 73
Wiconisco Creek 74
Armstrong Creek 74
Powell Creek 75
Susquehanna River in the northern section of the subbasin 75

Central Section Streams 75

Sherman Creek 75
Clark Creek 76
Stony Creek 76
Paxton Creek 76
Conodoguinet Creek Watershed 76
Yellow Breeches Creek 78
Swatara Creek Watershed 78
East Conewago Creek 79
Susquehanna River in the central section of the subbasin 80

Southern Section Streams 80

West Conewago Creek Watershed 80
Codorus Creek Watershed 82
Chickies Creek 83
Kreutz Creek 83
Conestoga Creek Watershed 83
Pequea Creek 85
Muddy Creek 85
Conowingo Creek 86
Octoraro Creek Watershed 86
Deer Creek 86
Susquehanna River in the southern section of the subbasin 87

Summary of Reference Categories 87

Reference category 64ac 87
Reference category 64d 87
Reference category 64L 87
Reference category 67a 90
Reference category 67b 90
Reference category 67cd 90
Reference category 67L 90

MANAGEMENT IMPLICATIONS 90

Reference Category 64ac, Small Northern Piedmont Uplands or Triassic Lowland Streams 91
Reference Category 64d, Small Northern Piedmont Limestone Lowland Streams 91
Reference Category 64L, Large Northern Piedmont Streams 91
Reference Category 67a, Small Limestone Valley Streams in the Central Appalachian Ridge and Valley Ecoregion 91
Reference Category 67b, Small Shale or Slate Noncalcareous Valley Streams in the Central Appalachian Ridge and Valley Ecoregion 92
Reference Category 67cd, Small Sandstone or Shale Ridge Streams in the Central Appalachian Ridge and Valley Ecoregion 92
Reference Category 67L, Large Central Appalachian Ridge and Valley Streams 92

CONCLUSIONS 92

REFERENCES 95

APPENDIXES

A. ORGANIC POLLUTION-TOLERANCE VALUES AND FUNCTIONAL FEEDING GROUP DESIGNATIONS OF BENTHIC MACROINVERTEBRATE TAXA 97

B. RAW BENTHIC MACROINVERTEBRATE DATA FROM SAMPLE SITES IN THE LOWER SUSQUEHANNA SUBBASIN 103

C. DRAINAGE AREA AND SUBECOREGION DESIGNATION 143

D. RAW WATER QUALITY DATA FROM SAMPLE SITES IN THE LOWER SUSQUEHANNA SUBBASIN 147

ILLUSTRATIONS

1. Map of Northern Section Sample Sites 2

2. Map of Central Section Sample Sites 3

3. Map of Southern Section Sample Sites 4

4. Map of Reference Category 64ac Sample Sites 19

5. Ordinations of Reference Category 64ac Sample Sites Based on Principal Components Analysis of Water Quality 20

6. Cluster Analysis of Water Quality Parameters That Account for Most of the Variability in Reference Category 64ac Water Quality Data 21

7. Summary of Reference Category 64ac RBP III Biological and Habitat Data 24

8. Map of Reference Category 64d Sample Sites 25

9. Ordinations of Reference Category 64d Sample Sites Based on Principal Components Analysis of Water Quality 26

10. Cluster Analysis of Water Quality Parameters That Account for Most of the Variability in Reference Category 64d Water Quality Data 27

11. Summary of Reference Category 64d RBP III Biological and Habitat Data 30

12. Map of Reference Category 64L Sample Sites 31

13. Ordinations of Reference Category 64L Sample Sites Based on Principal Components Analysis of Water Quality 32

14. Cluster Analysis of Water Quality Parameters That Account for Most of the Variability in Reference Category 64LWater Quality Data 33

15. Summary of Reference Category 64L RBP III Biological and Habitat Data 37

16. Map of Reference Category 67a Sample Sites 41

17. Ordinations of Reference Category 67a Sample Sites Based on Principal Components Analysis of Water Quality 42

18. Cluster Analysis of Water Quality Parameters That Account for Most of the Variability in Reference Category 67a Water Quality Data 43

19. Summary of Reference Category 67a RBP III Biological and Habitat Data 44

20. Map of Reference Category 67b Sample Sites 45

21. Ordinations of Reference Category 67b Sample Sites Based on Principal Components Analysis of Water Quality 46

22. Cluster Analysis of Water Quality Parameters That Account for Most of the Variability in Reference Category 67b Water Quality Data 47

23. Summary of Reference Category 67b RBP III Biological and Habitat Data 51

24. Map of Reference Category 67cd Sample Sites 52

25. Ordinations of Reference Category 67cd Sample Sites Based on Principal Components Analysis of Water Quality 53

26. Cluster Analysis of Water Quality Parameters That Account for Most of the Variability in Reference Category 67cd Water Quality Data 54

27. Summary of Reference Category 67cd RBP III Biological and Habitat Data 57

28. Map of Reference Category 67L Sample Sites 58

29. Ordinations of Reference Category 67L Sample Sites Based on Principal Components Analysis of Water Quality 59

30. Cluster Analysis of Water Quality Parameters That Account for Most of the Variability in Reference Category 67L Water Quality Data 60

31. Summary of Reference Category 67L RBP III Biological and Habitat Data 63

32. Map of Susquehanna River Sample Sites 65

33. Ordinations of Susquehanna River Sample Sites Based on Principal Components Analysis of Water Quality 66

34. Cluster Analysis of Water Quality Parameters That Account for Most of the Variability in Susquehanna River Sample Sites Water Quality Data 67

35. Summary of Susquehanna River Sample Sites RBP III Biological and Habitat Data 70

TABLES

1. Lower Susquehanna Subbasin Survey Sample Site Locations 6

2. Chemical Water Quality Parameters 8

3. Criteria Used to Evaluate Physical Habitat Parameters 10

4. Summary of Reference Category Delineation Criteria 14

5. Summary of Criteria Used to Classify the Habitat Conditions of Sample Sites 15

6. Summary of Metrics Used to Evaluate Overall Biological Integrity of Stream and River Benthic Macroinvertebrate Communities 16

7. Summary of Criteria Used to Classify the Biological Conditions of Sample Sites 17

8. Summary of Reference Category 64ac RBP III Habitat Data 22

9. Summary of Reference Category 64ac RBP III Biological Data 23

10. Summary of Reference Category 64d RBP III Habitat Data 28

11. Summary of Reference Category 64d RBP III Biological Data 29

12. Summary of Reference Category 64L RBP III Habitat Data 34

13. Summary of Reference Category 64L RBP III Biological Data 35

14. Summary of Reference Category 66 and 67a RBP III Habitat Data 38

15. Summary of Reference Category 66 and 67a RBP III Biological Data 39

16. Summary of Reference Category 67b RBP III Habitat Data 48

17. Summary of Reference Category 67b RBP III Biological Data 49

18. Summary of Reference Category 67cd RBP III Habitat Data 55

19. Summary of Reference Category 67cd RBP III Biological Data 56

20. Summary of Reference Category 67L RBP III Habitat Data 61

21. Summary of Reference Category 67L RBP III Biological Data 62

22. Summary of Susquehanna River RBP III Habitat Data 68

23. Summary of Susquehanna River RBP III Biological Data 69

24. Summary of the Physical Habitat and Biological Conditions of Sample Sites in the Lower Susquehanna Subbasin 88

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WATER QUALITY AND BIOLOGICAL ASSESSMENT OF THE LOWER SUSQUEHANNA SUBBASIN

Carrie L. Traver

ABSTRACT

The U.S. Environmental Protection Agency's Rapid Bioassessment Protocol III and multivariate statistical analyses were used to assess the condition of the biological community, physical habitat, and chemical water quality of 96 sample sites in the Lower Susquehanna Subbasin in central Pennsylvania and northeastern Maryland. Results of this assessment indicate that the majority of stream reaches (49 percent) surveyed displayed slight biological impairment. Relationships among physical habitat conditions, water quality, and stream biological conditions within the Lower Susquehanna Subbasin vary based on ecoregion designation and drainage area size; these relationships were explored through the use of principal components and correlation statistical analyses.

INTRODUCTION

The Susquehanna River drains an area of 27,510 square miles and has one of the largest river basins on the East Coast of the United States. It originates at Otsego Lake in New York State and flows 444 miles to the Chesapeake Bay at Havre de Grace, Maryland. The Susquehanna basin is comprised of six major subbasins.

The Lower Susquehanna is the southernmost subbasin. It encompasses the drainage area from the confluence of the Susquehanna River and West Branch Susquehanna River to the Chesapeake Bay (excluding the watershed of the Juniata River) (Figures 1 through 3). It drains 5,913 square miles in south central Pennsylvania and northern Maryland, and includes portions of three physiographic provinces: Blue Ridge Mountains, Northern Piedmont, and Central Appalachian Ridge and Valley.

Of the six subbasins, the Lower Susquehanna Subbasin is the most developed. Major population and industrial centers are situated within the subbasin, including Pennsylvania's state capital, Harrisburg, as well as Lancaster, York, Lebanon, and Carlisle. Residential and commercial activities are rapidly expanding in suburban areas. This subbasin also is known for its value as a productive agricultural area.

In the 1980s, Brezina (1980) and McMorran (1986) concluded that the biological communities of a number of streams in the Lower Susquehanna Subbasin were impacted by various point and nonpoint source pollution. Since those assessments, more robust bioassessment procedures have been developed in an attempt to incorporate the effects of stream size, geology, soils, and other "natural" landscape features into stream assessments to better differentiate "natural" stream ecosystems from those impaired by human activities. One such set of procedures termed Rapid Bioassessment Protocols (RBPs) has been developed by the United States Environmental Protection Agency (US EPA) (Plafkin and others, 1989).

The purpose of Rapid Bioassessment Protocol III (RBP III) is to provide a scientifically valid, cost-effective monitoring procedure for assessing the biological conditions of streams and rivers. RBP III is primarily based on benthic macroinvertebrate community data and physical

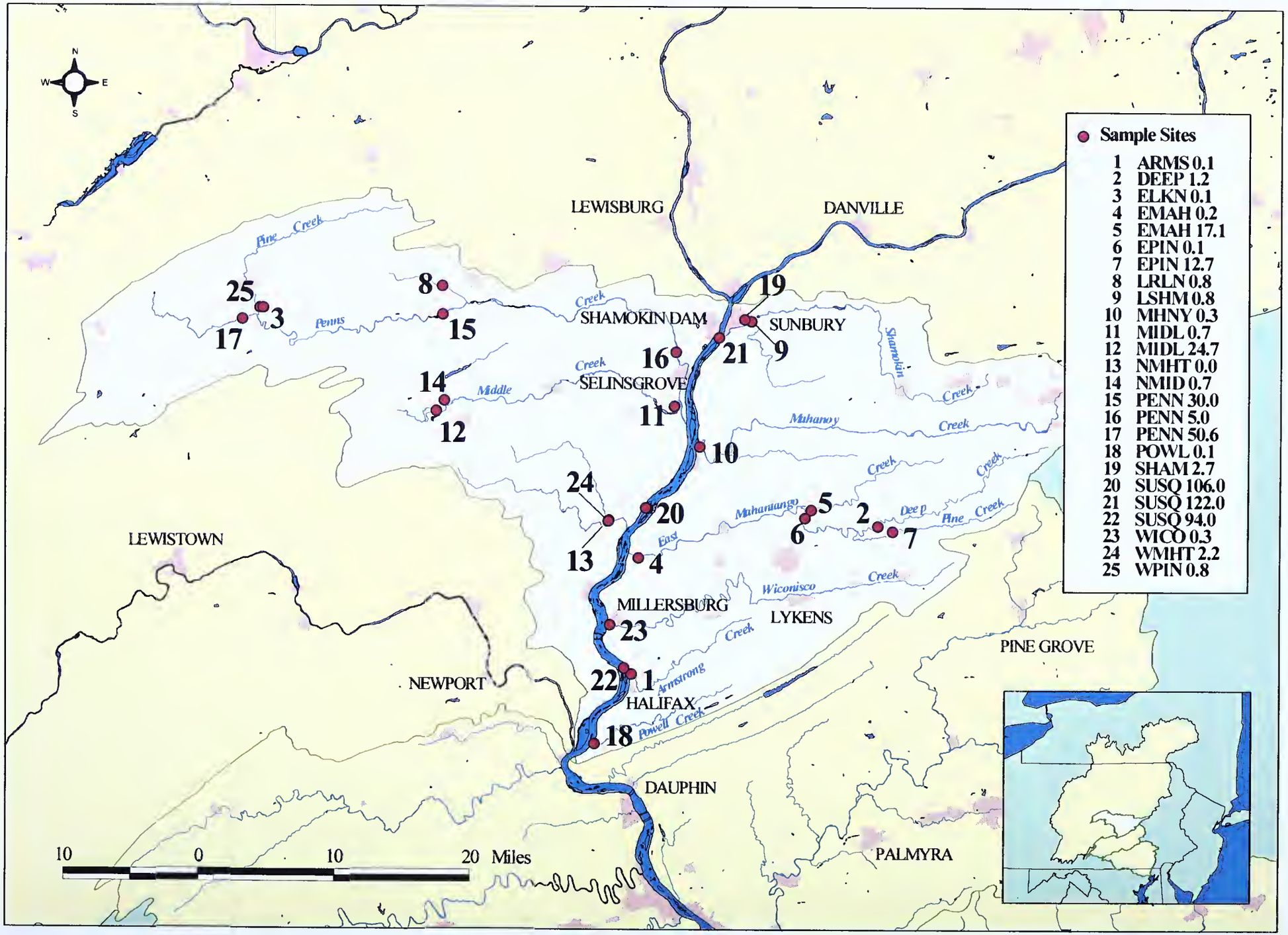


Figure 1. Map of Northern Section Sample Sites

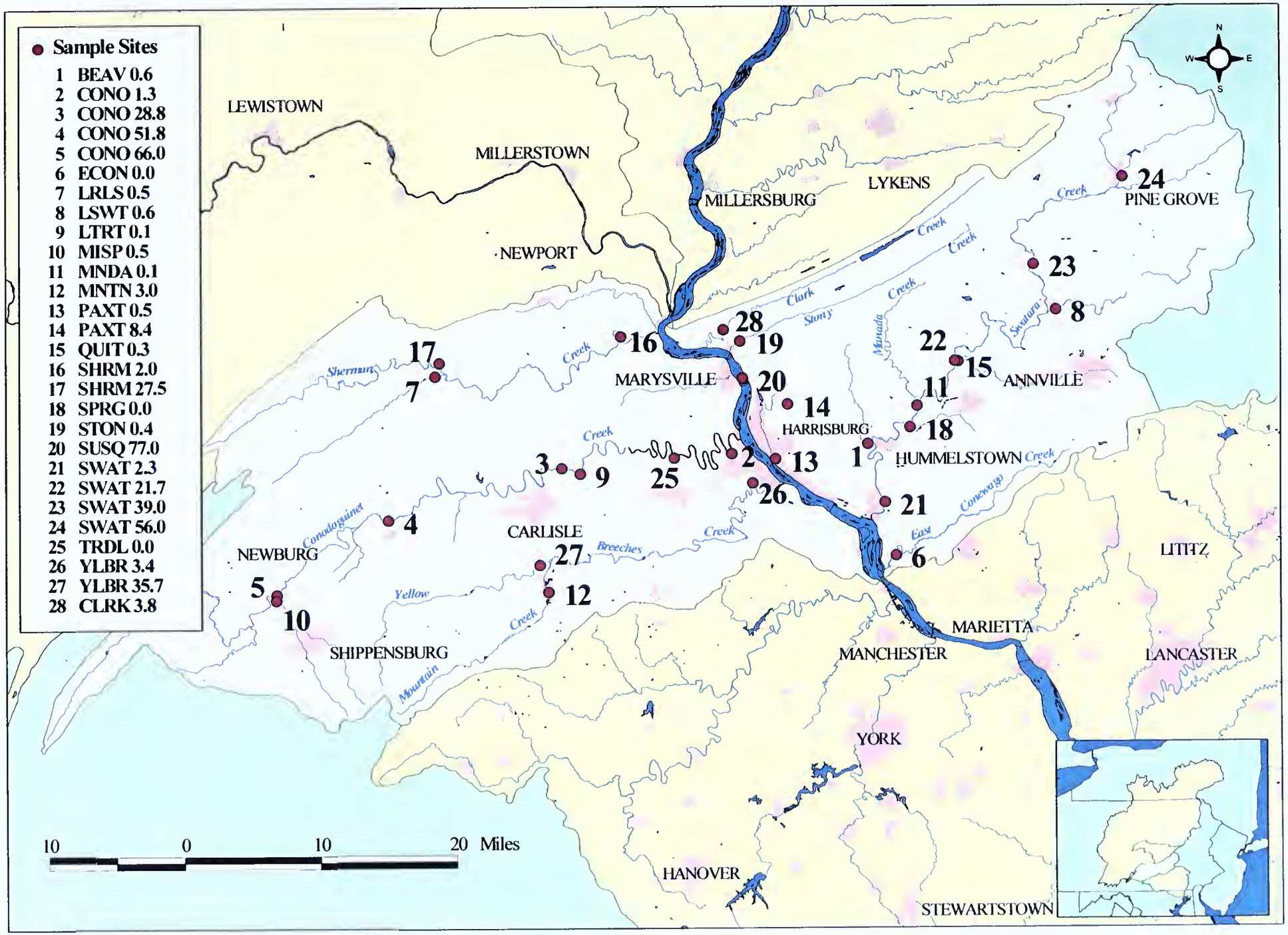


Figure 2. Map of Central Section Sample Sites

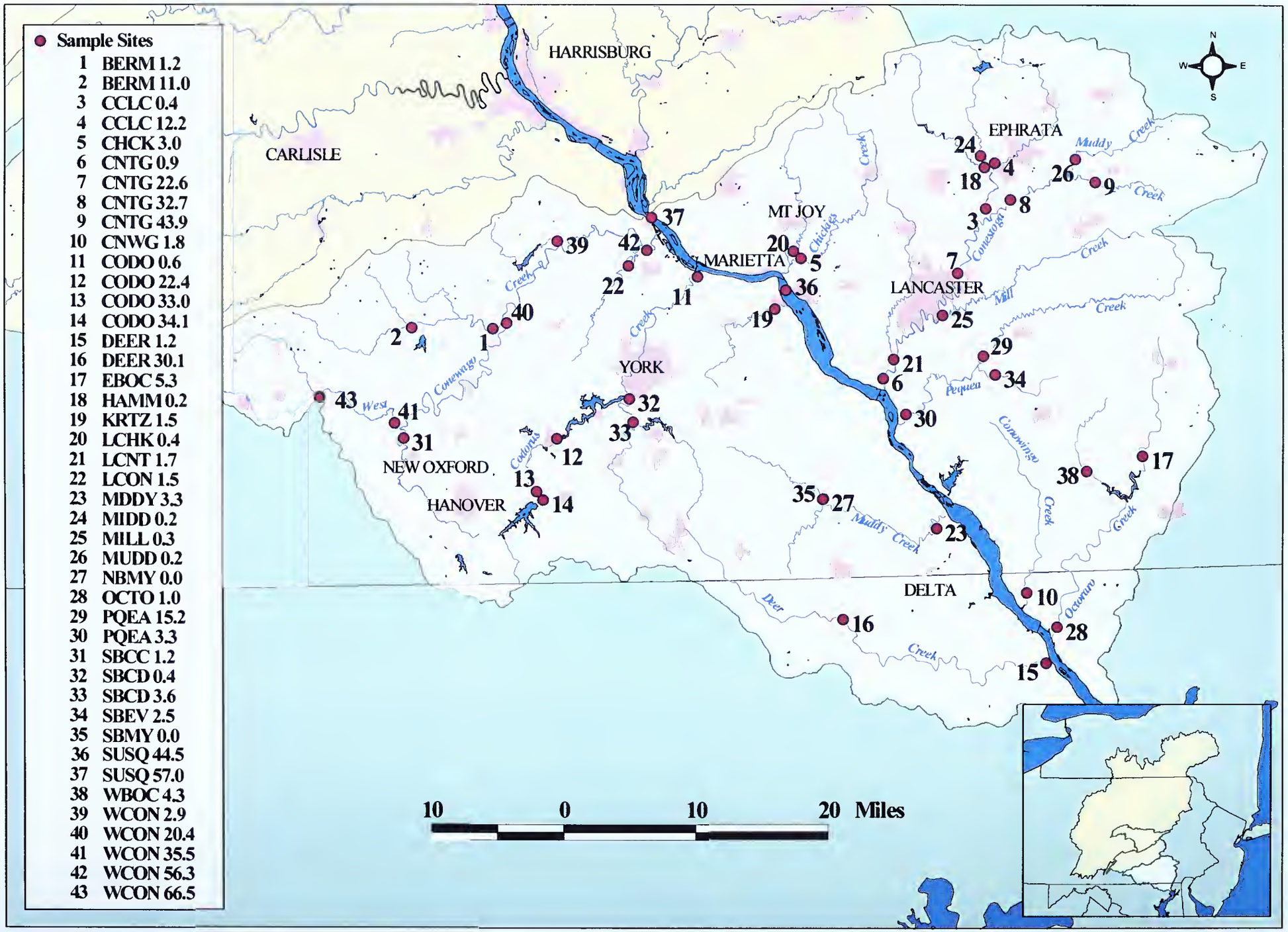


Figure 3. Map of Southern Section Sample Sites

habitat conditions. Only a limited number of measured parameters (temperature, pH, conductivity, and dissolved oxygen) are included in the chemical water quality component to reduce staff requirements and laboratory costs.

In some cases, RBP III data can be used to determine that either degraded physical habitat or water quality conditions are responsible for impaired biological conditions at a given sample site. For example, when a severely impaired biological community occurs in conjunction with good or excellent physical habitat conditions, biological impairment can usually be attributed to poor water quality. However, when a stream exhibits intermediate degrees of both habitat degradation and biological impairment, it is more difficult to assess the source of biological impairment based solely on RBP III data.

In this study, Susquehanna River Basin Commission (SRBC) staff used RBP III habitat and biological data in conjunction with the analysis of 37 chemical water quality parameters in an extensive bioassessment of the streams and rivers in the Lower Susquehanna Subbasin. The water quality component of RBP III was expanded to better identify sources of biological impairment.

The primary objectives of this report are to: (1) provide information to the Pennsylvania Department of Environmental Protection (Pa. DEP) and SRBC for Section 305(B) Water Quality Inventories; (2) identify the existence, severity, and probable source(s) of impairments to stream biological communities; (3) use standardized methods to build a database that can be used as baseline data for trend monitoring; and (4) identify relationships among landscape features, ecoregion, physical habitat, water quality conditions, and stream biological conditions. Findings and management issues are presented for consideration by natural resource managers and policy makers.

METHODS

Field and Laboratory Methods

Field data were collected during a period of little or no precipitation when streamflows were maintained primarily by baseflow. Ninety-six sites (Figures 1 through 3) were sampled in the Lower Susquehanna Subbasin between July 8 and August 15, 1996. Six sites were located on the main stem of the Susquehanna River, and 90 sites were distributed among 61 tributaries (Table 1). Physical habitat was documented at each sample site, and benthic macroinvertebrate and chemical water quality samples were collected for analysis in the laboratory. However, high flow conditions prohibited macroinvertebrate collection at one site (SWAT 21.7).

Chemical water quality

Water samples were collected at each site for laboratory analysis. Field water quality measurements included water temperature, dissolved oxygen, conductivity, pH, alkalinity, and acidity. (See Table 2 for a complete list of measured parameters.) Temperature and dissolved oxygen were measured using a YSI Model 55 dissolved oxygen meter. The dissolved oxygen meter was calibrated at the beginning of each day when water samples were collected. Conductivity was measured using a VWR Scientific Model 2052 conductivity meter. A Cole Parmer meter was used to measure pH. Alkalinity was measured by titrating a known volume of sample water to pH 4.5 with 0.02N sulfuric acid (H_2SO_4). Acidity was measured by titrating a known volume of sample water to pH 8.3 with 0.02N sodium hydroxide (NaOH). Approximately 2 liters of water from each site were collected for laboratory analysis.

Table 1. Lower Susquehanna Subbasin Survey Sample Site Locations

Station	Site Description	Latitude	Longitude
ARMS 0.1	Armstrong Creek at Halifax	402901	765558
BEAV 0.6	Beaver Creek at Second Bridge	401558	764418
BERM 1.2	Bermudian Creek at Blue Hill School Bridge	395957	765631
BERM 11.0	Bermudian Creek downstream of Latimore Creek	400005	770329
CCLC 0.4	Cocalico Creek upstream of Conestoga Creek	400710	761408
CCLC 12.2	Cocalico Creek at Garden Spot Road	401009	761316
CHCK 3.0	Chickies Creek at Habecker Road Bridge	400411	763001
CLRK 3.8	Clark Creek near Rte. 225 Bridge	402318	765629
CNTG 0.9	Conestoga Creek at River Road	395614	762315
CNTG 22.6	Conestoga Creek at gage	400300	761639
CNTG 32.7	Conestoga Creek upstream of Cocalico Creek	400743	761159
CNTG 43.9	Conestoga Creek upstream of Muddy Creek	400845	760442
CNWG 1.8	Conowingo Creek near the mouth	394200	761123
CODO 0.6	Codorus Creek at Codorus Furnace	400307	763855
CODO 22.4	Codorus Creek at Rte. 516 Bridge	395243	765113
CODO 33.0	Codorus Creek downstream of West Branch	394917	765302
CODO 34.1	Codorus Creek downstream of Valley Junction	394844	765229
CONO 1.3	Conodoguinet Creek near the mouth	401521	765540
CONO 28.8	Conodoguinet Bridge at Wolfs Bridge Road	401424	770953
CONO 51.8	Conodoguinet Creek upstream of Rte. 233 Bridge	401103	772424
CONO 66.0	Conodoguinet Creek at Burnt Mill Road Bridge	400616	773339
DEEP 1.2	Deep Creek near Sacramento	403829	763517
DEER 1.2	Deer Creek near the mouth	393721	760954
DEER 30.1	Deer Creek near Rte. 165	394030	762706
EBOC 5.3	East Branch Octoraro Creek at lower 36022 Bridge	395046	760115
ECON 0.0	East Conewago Creek at Rte. 441	400851	764158
ELKN 0.1	Elk Creek at Coburn	405209	772731
EMAH 0.2	East Mahantango Creek at Rte. 147 Bridge	403626	765527
EMAH 17.1	East Mahantango Creek at Klingerstown	403931	764054
EPIN 0.1	Pine Creek near Klingerstown	403901	764127
EPIN 12.7	Pine Creek near Sacramento	403809	763405
HAMM 0.2	Hammer Creek upstream of Cocalico Creek	400953	761409
KRTZ 1.5	Kreutz Creek at Cool Brook Road	400055	763222
LCHK 0.4	Little Chickies Creek upstream of Chickies Creek	400441	763039
LCNT 1.7	Little Conestoga Creek	395728	762218
LCON 1.5	Little Conewago Creek at Big Conewago Road	400355	764450
LRLN 0.8	Laurel Run at Laurelton	405339	771209
LRLS 0.5	Laurel Run near the mouth	402013	772032
LSHM 0.8	Little Shamokin Creek near Sunbury	405130	764600
LSWT 0.6	Little Swatara Creek at Jonestown	402428	762831
LTRT 0.1	Letort Spring Run at Rte. 11	401403	770822
MDDY 3.3	Muddy Creek near the mouth	394621	761858
MHNY 0.3	Mahanoy Creek at Rte. 147 Bridge	404332	765018
MIDD 0.2	Middle Creek at Middle Creek Road Bridge	401038	761427
MIDL 0.7	Middle Creek near the mouth	404607	765229
MIDL 24.7	Middle Creek at Rte. 235 Bridge	404543	771235
MILL 0.3	Mill Creek at Elkman Road Bridge	400017	761803
MISP 0.5	Middle Spring Run at Burnt Mill Road	400554	773342
MNDA 0.1	Manada Creek upstream of Sand Beach Creek	401822	764010

Table 1. Lower Susquehanna Subbasin Survey Sample Site Locations—Continued

Station	Site Description	Latitude	Longitude
MNTN 3.0	Mountain Creek upstream of Rte. 34 Bridge	400630	771059
MUDD 0.2	Muddy Creek upstream of Conestoga Creek	401015	760621
NBMY 0.0	North Branch Muddy Creek at the mouth	394828	762834
NMHT 0.0	North Mahantango Creek at Rte. 104 Bridge	403851	765758
NMID 0.7	North Branch Middle Creek at Benfer	404624	771155
OCTO 1.0	Octoraro Creek at Rowlandsville	393940	760854
PAXT 0.5	Paxton Creek at Sycamore St.	401501	765201
PAXT 8.4	Paxton Creek at Progress Ave.	401829	765100
PENN 30.0	Penns Creek at Glen Iron	405151	771206
PENN 5.0	Penns Creek at Selinsgrove	404932	765222
PENN 50.6	Penns Creek at Coburn	405126	772900
POWL 0.1	Powell Creek near Rte. 147 Bridge	402435	765903
PQEA 15.2	Pequea Creek at Rte. 222 Bridge	395733	761439
PQEA 3.3	Pequea Creek at Rte. 324 Bridge	395353	762122
QUIT 0.3	Quittapahilla Creek at the mouth	402110	763643
SBCC 1.2	South Branch Conewago Creek at the mouth	395255	770419
SBCD 0.4	South Branch Codorus Creek at gage	395514	764457
SBCD 3.6	South Branch Codorus upstream of East Branch	395343	764440
SBEV 2.5	Big Beaver Creek at Refton Railroad Bridge	395619	761339
SBMY 0.0	South Branch Muddy Creek at the mouth	394827	762835
SHAM 2.7	Shamokin Creek at Sunbury	405137	764634
SHRM 2.0	Sherman Creek near the mouth	402247	770456
SHRM 27.5	Sherman Creek near Boy Scout Camp	402103	772009
SPRG 0.0	Spring Creek at confluence	401701	764046
STON 0.4	Stony Creek upstream of dam at Dauphin	402231	765457
SUSQ 44.5	Susquehanna River at Columbia	400209	763124
SUSQ 57.0	Susquehanna River at Three Mile Island	400704	764245
SUSQ 77.0	Susquehanna River at Fort Hunter	402009	765445
SUSQ 106.0	Susquehanna River at Mckees Half Falls	403939	765451
SUSQ 122.0	Susquehanna River below Fabridam	405029	764843
SUSQ 94.0	Susquehanna River at Halifax	402924	765636
SWAT 2.3	Swatara Creek downstream of Turnpike Bridge	401215	764251
SWAT 21.7	Swatara Creek upstream of Quittapahilla Creek	402112	763659
SWAT 39.0	Swatara Creek upstream of Little Swatara Creek	402722	763021
SWAT 56.0	Swatara Creek downstream of upper Little Swatara Creek	403255	762249
TRDL 0.0	Trindle Spring Run at Silver Springs	401505	770028
WBOC 4.3	West Branch Octoraro Creek upstream of reservoir	394952	760602
WCON 2.9	West Conewago Creek at Rte. 182 Bridge	400456	764313
WCON 20.4	West Conewago Creek at Bull Road Bridge	400537	765052
WCON 35.5	West Conewago Creek upstream of Bermudian Creek	400018	765521
WCON 56.3	West Conewago Creek upstream of South Branch	395355	770504
WCON 66.5	West Conewago Creek upstream of Opossum Creek	395539	771125
WICO 0.3	Wiconisco Creek at the mouth	403209	765750
WMHT 2.2	West Mahantango Creek at Rte. 104 Bridge	403848	765759
WPIN 0.8	Pine Creek at Coburn	405210	772714
YLBR 3.4	Yellow Breeches Creek at gage	401329	765354
YLBR 35.7	Yellow Breeches Creek upstream of Mountain Creek	400813	771144

Table 2. Chemical Water Quality Parameters

Parameter	Symbol	Units	Parameter	Symbol	Units
Field-Measured Parameters					
Water Temperature	Temp	Degrees C	Conductivity	Cond	µ ohms/cm
pH	pH	S.U.	Alkalinity	Alk	mg/L
Dissolved Oxygen	DO	mg/L	Acidity	Acid	mg/L
Laboratory Analysis					
Specific Conductivity	Lab cond	µ ohms/cm	Total Calcium	Ca	mg/L
pH	Lab pH	mg/L	Magnesium	Mg	mg/L
Alkalinity (as CaCO3)	Lab Alk	mg/L	Sodium	Na	mg/L
Dissolved Residuals	D Res	mg/L	Potassium	K	mg/L
Total Residuals	T Res	mg/L	Chloride	Cl	mg/L
Total Nitrogen	TN	mg/L	Total Sulfate	SO_4	mg/L
Dissolved Nitrogen	DN	mg/L	Fluoride	Fl	mg/L
Dissolved Ammonia	DNH_3	mg/L	Copper	Cu	µg/L
Total Ammonia	TNH_3	mg/L	Total Iron	TFe	µg/L
Dissolved Nitrite	DNO_2	mg/L	Dissolved Iron	DFe	µg/L
Total Nitrite	TNO_2	mg/L	Lead	Pb	µg/L
Dissolved Nitrate	DNO_3	mg/L	Total Manganese	TMn	µg/L
Total Nitrate	TNO_3	mg/L	Dissolved Manganese	DMn	µg/L
Total Phosphorus	TP	mg/L	Nickel	Ni	µg/L
Dissolved Phosphorus	DP	mg/L	Zinc	Zn	µg/L
Total Organic Carbon	TOC	mg/L	Total Aluminum	TAl	µg/L
Total Hardness ($CaCO_3$)	Hard	mg/L	Dissolved Aluminum	DAl	µg/L

Laboratory samples consisted of two 500 mL samples for nutrient analysis and two 500 mL samples for metal analysis. For both analyses, one sample was filtered with a cellulose nitrate filter with 0.45 micrometer pore size. The samples for metal analyses were acidified to pH 2 or less with nitric acid. All samples were chilled on ice and shipped within 24 hours to the Pa. DEP Bureau of Laboratories in Harrisburg, Pa.

Physical habitat and biological conditions

Physical habitat conditions at each sample site were assessed using a slightly modified version of the habitat assessment procedure outlined by Plafkin and others (1989). A total of 11 habitat parameters were field-evaluated at each site and used to calculate a site-specific habitat assessment score. Habitat parameters were identified as primary, secondary, or tertiary parameters based on their contribution to habitat quality. Primary parameters, stream habitat features that have the greatest direct influence on the structure of aquatic communities, were evaluated on a scale of 0-20 and included the characterization of stream bottom substrate and instream cover, embeddedness, and velocity/depth diversity. Secondary parameters included stream channel morphology characteristics and were scored on a scale of 0-15. Tertiary parameters characterized riparian and bank conditions and were scored on a scale of 0-10. The criteria used to evaluate habitat parameters are summarized in Table 3.

Benthic macroinvertebrate samples were collected and analyzed using field and laboratory methods described by Plafkin and others (1989). Sampling was performed using a 1 meter square kick net with size No. 30 mesh to collect organisms dislodged from riffle areas by physical agitation of the streambed. Two areas of the streambed, each approximately 1 meter square, were sampled at each site: one area of high velocity, and one area of lower velocity. The two samples were composited and preserved in a solution of isopropyl alcohol and glycerin for laboratory analysis. In the laboratory, composite samples were sorted into 100-organism subsamples using a gridded pan and a random numbers table. The organisms contained in the subsamples were identified to genus (with the exception of Chironomidae, Simuliidae, Dixidae, Hydracarina, and Tubificidae) and enumerated. Each taxon was assigned an organic pollution tolerance value and a functional feeding category as outlined in Appendix A. Raw invertebrate data for each site are listed in Appendix B.

Data Analysis Methods

Reference category designation

Sample sites were grouped into reference categories based on: (1) ecoregion designation; (2) drainage area size; and (3) subecoregion designation. Sites with drainage areas less than 100 square miles in Subecoregions 64a (Triassic lowlands) and 64c (Piedmont uplands) were combined into a single reference category, due to the limited number of sites located in Subecoregion 64a. Sites with drainage areas less than 100 square miles in Subecoregions 67c (sandstone ridges) and 67d (shale ridges) were combined into a single reference category, due to the relative similarity between these two subecoregions and the limited number of sites located in Subecoregion 67d. For each reference category, one site that represented a combination of the "least disturbed or best attainable" habitat and biological conditions was identified and used as the reference site for the reference category. Reference category delineation criteria are summarized in Table 4. Drainage area and subecoregion designation are listed in Appendix C.

Chemical water quality

Principal components analysis (PCA) was used to condense the water quality data into a manageable format, to reveal structure in the data, and to efficiently describe the water quality characteristics of the sample sites within a given reference category. PCA results are presented as graphs (ordinations), in which the axes represent subsets of the parameters included in the analysis that account for most of the variation in the data.

Table 3. Criteria Used to Evaluate Physical Habitat Parameters

Habitat Parameter	Excellent	Good	Fair	Poor
1. Bottom Substrate	Greater than 50% cobble, gravel, submerged logs, undercut banks, or other stable habitat **(16-20)**	30-50% cobble, gravel, or other stable habitat. Adequate habitat. **(11-15)**	10-30% cobble, gravel, or other stable habitat. Habitat availability is less than desirable. **(6-10)**	Less than 10% cobble, gravel, or other stable habitat. Lack of habitat is obvious. **(0-5)**
2. Embeddedness (a)	Larger substrate particles (e.g., gravel, cobble, boulders) are between 0 and 25% surrounded by fine sediment. **(16-20)**	Larger substrate particles (e.g., gravel, cobble, boulders) are between 25 and 50% surrounded by fine sediment. **(11-15)**	Larger substrate particles (e.g., gravel, cobble, boulders) are between 50 and 75% surrounded by fine sediment. **(6-10)**	Larger substrate particles (e.g., gravel, cobble, boulders) are over 75% surrounded by fine sediment. **(0-5)**
3. Velocity/Depth Diversity	Four habitat categories consisting of slow (<1.0 ft/s), deep (>1.5 ft); slow, shallow (<1.5 ft); fast (> 1.0 ft/s), deep; fast, shallow habitats are all present. **(16-20)**	Only 3 of the 4 habitat categories are present. **(11-15)**	Only 2 of the 4 habitat categories are present. **(6-10)**	Dominated by 1 velocity/depth category (usually pools). **(0-5)**
4. Pool/Riffle Ratio (or Run/Bend)	Distance between riffles divided by mean wetted width equals 5-7. Stream contains a variety of habitats including deep riffles and pools. **(12-15)**	Distance between riffles divided by mean wetted width equals 7-15. Adequate depth in pools and riffles. **(8-11)**	Distance between riffles divided by mean wetted width equals 15-25. Stream contains occasional riffles. **(4-7)**	Distance between riffles divided by mean wetted width >25. Stream is essentially straight with all flat water or shallow riffle. Poor habitat. **(0-3)**
5. Pool Quality (b)	Pool habitat contains both deep (>1.5 ft) and shallow areas (<1.5 ft) with complex cover and/or depth greater than 5 ft. **(12-15)**	Pool habitat contains both deep (>1.5 ft) and shallow (<1.5 ft) areas with some cover present. **(8-11)**	Pool habitat consists primarily of shallow (<1.5 ft) areas with little cover. **(4-7)**	Pool habitat rare with maximum depth <0.5 ft, or pool habitat completely absent. **(0-3)**

Table 3. Criteria Used to Evaluate Physical Habitat Parameters—Continued

Habitat Parameter	Excellent	Good	Fair	Poor
6. **Riffle/Run Quality** (c)	Riffle/run depth generally >8 in. and consisting of stable substrate materials and a variety of current velocities. **(12-15)**	Riffle/run depth generally 4-8 in. and with a variety of current velocities. **(8-11)**	Riffle/run depth generally 1-4 in.; primarily a single current velocity. **(4-7)**	Riffle/run depth <1 in.; or riffle/run substrates concreted. **(0-3)**
7. **Channel Alteration** (d)	Little or no enlargement of islands or point bars, and/or no channelization. **(12-15)**	Some new increase in bar formation, mostly from coarse gravel; and/or some channelization present. **(8-11)**	Moderate deposition of new gravel, coarse sand on old and new bars; pools partially filled with silt; and/or embankments on both banks. **(4-7)**	Heavy deposits of fine material, increased bar development; most pools filled with silt; and/or extensive channelization. **(0-3)**
8. **Upper and Lower Streambank Erosion** (e)	Stable. No evidence of erosion or of bank failure. Side slopes generally <30%. Little potential for future problems. **(9-10)**	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. **(6-8)**	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% in some areas. High erosion potential during extreme high flow. **(3-5)**	Unstable. Many eroded areas. Side slopes >60% common. "Raw" areas frequent along straight sections and bends. **(0-2)**
9 **Upper and Lower Streambank Stability** (e)	Over 80% of the streambank surface is covered by vegetation or boulders and cobble. **(9-10)**	50-79% of the streambank surface is covered by vegetation, gravel, or larger material. **(6-8)**	25-49% of the streambank surface is covered by vegetation, gravel, or larger material. **(3-5)**	Less than 25% of the streambank surface is covered by vegetation, gravel, or larger material. **(0-2)**
10. **Streamside Vegetative Cover** ***(Both Banks)***	Dominant vegetation that provides stream-shading, escape cover, and/or refuge for fish within the bankfull stream channel is shrub. **(9-10)**	Dominant vegetation that provides stream shading, escape cover, and/or refuge for fish within the bankfull stream channel is trees **(6-8)**	Dominant vegetation that provides stream-shading, escape cover, and/or refuge for fish within the bankfull stream channel is forbs and grasses. **(3-5)**	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. **(0-2)**

Table 3. Criteria Used to Evaluate Physical Habitat Parameters—Continued

Habitat Parameter	Excellent	Good	Fair	Poor
11. Forested Riparian Buffer Zone Width (f) ***(Least Forested Bank)***	Riparian area consists of all three zones of vegetation, Zones 1-3. (See zone descriptions (e).) **(9-10)**	Riparian area consists of Zones 1 and 2. **(6-8)**	Riparian area is limited primarily to Zone 1. Zone 2 may be forested but is subject to disturbance (e.g., grazing, intensive forestry practices, roads). **(3-5)**	Riparian area lacks Zone 1 with or without Zones 2 and/or 3. **(0-2)**

(a) Embeddedness — The degree to which the substrate materials that serve as habitat for benthic macroinvertebrates and for fish spawning and egg incubation (predominantly cobble and/or gravel) are surrounded by fine sediment. Embeddedness is evaluated with respect to the suitability of these substrate materials as habitat for macroinvertebrates and fish by providing shelter from the current and predators, and by providing egg deposition and incubation sites.

(b) Pool Quality — Rated based on the variety and spatial complexity of slow- or still-water habitat within the sample segment. It should be noted that even in high-gradient segments, functionally important slow-water habitat may exist in the form of plunge-pools and/or larger eddies. Within a category, higher scores are assigned to segments that have undercut banks, woody debris, or other types of cover for fish.

(c) Riffle/Run Quality — Rated based on the depth, complexity, and functional importance of riffle/run habitat in the segment, with highest scores assigned to segments dominated by deeper riffle/run areas, stable substrates, and a variety of current velocities.

(d) Channel Alteration — A measure of large-scale changes in the shape of the stream channel. Channel alteration includes: concrete channels, artificial embankments, obvious straightening of the natural channel, rip-rap, or other structures, as well as recent sediment bar development. Sediment bars typically form on the inside of bends, below channel constrictions, and where stream gradient decreases. Bars tend to increase in depth and length with continued watershed disturbance. Ratings for this parameter are based on the presence of artificial structures as well as the existence, extent, and coarseness of sediment bars, which indicate the degree of flow fluctuations and substrate stability.

(e) Upper and Lower Streambank Erosion and Stability — These parameters include the concurrent assessment of both the upper and lower banks. The upper bank is the land area from the break in the general slope of the surrounding land to the top of the bankfull channel. The lower bank is the intermittently submerged portion of the stream cross section from the top of the bankfull channel to the existing water-line.

(f) Forested Riparian Buffer Zone Width — Zone 1: a 15-ft wide buffer of essentially undisturbed forest located immediately adjacent to the stream.
Zone 2: a 100-ft wide buffer of forest, located adjacent to Zone 1, which may be subject to non-intensive forest management practices.
Zone 3: a 20-ft wide buffer of vegetation, located adjacent to Zone 2, that provides sediment filtering and promotes the formation of sheet flow of runoff into Zone 2. Zone 3 may be composed of trees, shrubs, and/or dense grasses and forbs, which are subject to haying and grazing, as long as vegetation is maintained in vigorous condition.

Source: Modified from Plafkin and others, 1989.

Parameters that had low axis weightings, and thus accounted for only a small part of the overall variability in the data, were removed from the data set. This process was repeated until the original data set of 37 water quality parameters was condensed to a relatively small number of parameters that produced meaningful ordinations. Next, the condensed data set produced from PCA was used in a hierarchical, agglomerative cluster analysis to produce a dendrogram, a tree-like graph that shows the relative similarity of sample sites. Separate principal components and cluster analyses were performed for each reference category using software developed by Kovach (1993) and Minitab (1996), respectively. Principal components and cluster analyses were described by Gauch (1982).

Physical habitat and biological conditions

Data analysis of habitat and biological data follows the modified procedure of Plafkin and others (1989) developed by McGarrell (1997). Habitat assessment scores of sample sites were compared to those of reference sites to classify each sample site into a habitat condition category (Table 5). The biological integrity of each sample site was assessed using a modified version of RBP III, as described by Plafkin and others (1989). This modification included the substitution of several of the indices ("metrics") used to evaluate the overall integrity of the site's benthic macroinvertebrate community. These substitutions included: (1) Shannon Diversity (log base 2) for the Percent Contribution of Dominant Taxa Metric; (2) Percent Taxonomic Similarity for the EPT/Chironomidae Abundances and Community Loss Metrics; and (3) Percent Trophic Similarity for the Scrapers/Filtering Collectors and Shredders/Total Metrics. The metrics used in this survey are summarized in Table 6.

The 100-organism subsample data were used to generate scores for each of the six metrics. Each metric score was then converted to a biological condition score, based on the percent score of the appropriate reference site. The sum of the biological condition scores constituted the total biological score for the sample site, and total biological scores were used to assign each site to a biological condition category (Table 7).

Table 4. Summary of Reference Category Delineation Criteria

Ecoregion Designation (1)	Ecoregion 66 Blue Ridge Mountains	Ecoregion 64 Northern Piedmont			Ecoregion 67 Central Appalachian Ridge and Valley			
Drainage Area Size (2)	<100 sq. mi.	<100 sq. mi.		>100 sq. mi.	<100 sq. mi.			>100 sq. mi.
Subecoregion Designation (3)	66 Igneous or Shale Ridges	64a and 64c Triassic Lowlands or Piedmont Uplands	64d Piedmont Limestone Lowlands	N/A	67a Limestone or Dolomite Valleys	67b Shale or Slate Valleys	67c and 67d Sandstone or Shale Ridges	N\A
Reference Category	66	64ac	64d	64L	67a	67b	67cd	67L
Sample Sites	MNTN 3.0	BERM 11.0 CNWG 1.8 CODO 34.1 DEER 30.1 EBOC 5.3 ECON 0.0 LCON 1.5 NBMY 0.0 SBCC 1.2 SBCD 3.6 SBMY 0.0 WBOC 4.3	CCLC 12.2 HAMM 0.2 KRTZ 1.5 LCHK 0.4 LCNT1.7 MIDD 0.2 MILL 0.3 MUDD 0.2 SBEV 2.5	BERM 1.2 CHCK 3.0 CCLC 0.4 CNTG 0.9 CNTG 22.6 CNTG 32.7 CNTG 43.9 CODO 0.6 CODO 22.4 CODO 33.0 DEER 1.2 MDDY 3.3 OCTO 1.0 PQEA 3.3 PQEA 15.2 SBCD 0.4 SWAT 2.3 WCON 2.9 WCON 20.4 WCON 35.5 WCON 56.3 WCON 66.5	BEAV 0.6 ELKN 0.1 LTRT 0.1 MISP 0.5 PENN 50.6 SPRG 0.0 TRDL0.0 WPIN 0.8	ARMS 0.1 EMAH 17.1 LRLN 0.8 LSHM 0.8 LSWT 0.6 MIDL 24.7 MNDA 0.1 NMHT 0.0 NMID 0.7 PAXT 0.5 PAXT 8.4 POWL 0.1 QUIT 0.3 SWAT 39.0 SWAT 56.0 WMHT 2.2	CLRK 3.8 DEEP 1.2 EPIN 0.1 EPIN 12.7 LRLS 0.5 STON 0.4	CONO 1.3 CONO 28.8 CONO 51.8 CONO 66.0 EMAH 0.2 MHNY 0.3 MIDL 0.7 PENN 5.0 PENN 30.0 SHAM 2.7 SHRM 2.0 SHRM 27.5 SWAT 21.7 WICO 0.3 YLBR 3.4 YLBR 35.7
Reference Site		SMBY 0.0	PENN 50.6	MDDY 3.3	PENN 50.6	WMHT 2.2	STON 0.4	PENN 30.0

(1) Omernik (1987)
(2) Pa. DER (1989)
(3) Pa. DEP (unpublished)

Table 5. Summary of Criteria Used to Classify the Habitat Conditions of Sample Sites

DETERMINATION OF HABITAT ASSESSMENT SCORES				
	Habitat Parameter Scoring Criteria			
Parameter	Excellent	Good	Fair	Poor
Bottom Substrate	20-16	15-11	10-6	5-0
Embeddedness	20-16	15-11	10-6	5-0
Velocity/Depth Diversity	20-16	15-11	10-6	5-0
Pool-Riffle (Run-Bend) Ratio	15-12	11-8	7-4	3-0
Pool Quality	15-12	11-8	7-4	3-0
Riffle/Run Quality	15-12	11-8	7-4	3-0
Channel Alteration	15-12	11-8	7-4	3-0
Upper and Lower Streambank Erosion	10-9	8-6	5-3	2-0
Upper and Lower Streambank Stability	10-9	8-6	5-3	2-0
Streamside Vegetative Cover	10-9	8-6	5-3	2-0
Forested Riparian Buffer Zone Width	10-9	8-6	5-3	2-0

↓
↓

Habitat Assessment Score = Sum of Habitat Parameter Scores

↓
↓

HABITAT ASSESSMENT	
Percent Comparability of Study and Reference Site Habitat Assessment Scores	Habitat Condition Category
>90	Excellent (comparable to reference)
89-75	Supporting
74-60	Partially supporting
<60	Nonsupporting

Table 6. Summary of Metrics Used to Evaluate Overall Biological Integrity of Stream and River Benthic Macroinvertebrate Communities

Metric	Description
1. Taxonomic Richness (1)	The total number of taxa present in the 100 organism subsample
2. Shannon Diversity Index (2)	A measure of biological community complexity based on the number of equally or nearly equally abundant taxa in the community
3. Modified Hilsenhoff Biotic Index (1)	A measure of the overall pollution tolerance of a benthic macroinvertebrate community
4. EPT Index (1)	The total number of Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) taxa present in the 100 organism subsample
5. Percent Taxonomic Similarity (2)	A measure of the similarity between the taxonomic composition of the sample site and its appropriate reference community
6. Percent Trophic Similarity (2)	A measure of the similarity between the functional feeding group composition of a sample site and its appropriate reference community

Sources: (1) Plafkin and others (1989); and
(2) calculated using software developed by Kovach (1993).

Table 7. Summary of Criteria Used to Classify the Biological Conditions of Sample Sites

SAMPLING AND ANALYSIS

↓

TOTAL BIOLOGICAL SCORE DETERMINATION

Metric	Biological Condition Scoring Criteria (percent)			
	6	4	2	0
1. Taxonomic Richness (a)	>80	79 - 60	59 - 40	<40
2. Shannon Diversity Index (a)	>75	74 - 50	49 - 25	<25
3. Modified Hilsenhoff Biotic Index (b)	>85	84 - 70	69 - 50	<50
4. EPT Index (a)	>90	89 - 80	79 - 70	<70
5. Percent Taxonomic Similarity (c)	>45	44 - 33	32 - 20	<20
6. Percent Trophic Similarity (c.d)	>75	74 - 50	49 - 25	<25

↓

Total Biological Score = the sum of Biological Condition Scores assigned to each metric

↓

BIOASSESSMENT

Percent Comparability of Study and Reference Site Total Biological Scores	Biological Condition Category
>81	Nonimpaired
81-53	Slightly impaired
52-20	Moderately impaired
<20	Severely impaired

(a) Score is study site value/reference site value X 100.
(b) Score is reference site value/study site value X 100.
(c) Range of values obtained. A comparison to the reference station is incorporated in this index.
(d) Functional Feeding Group Designations are summarized in Appendix A.

RESULTS

Reference Category 64ac

Reference category 64ac consists of 12 sites located in the Triassic lowlands, the Arkosic sandstone uplands, and the Piedmont uplands of the Northern Piedmont Ecoregion (Ecoregion 64), with drainage areas of less than 100 square miles (Figure 4). PCA identifies a subset of 18 water quality parameters that account for most of the variation in the data. The results of principal components and cluster analyses are presented in Figures 5 and 6, respectively. Raw water quality data are tabulated in Appendix D.

The reference site for reference category 64ac is SMBY 0.0. The biological communities of two (17 percent) reference category 64ac sites are nonimpaired. The remaining ten (83 percent) support biological communities that are slightly impaired. Habitat conditions are excellent (comparable to reference) at a majority (83 percent) of the sites in this reference category. RBP III physical habitat and biological data are summarized in Tables 8 and 9 and Figure 7.

Reference Category 64d

Nine sample sites are included in reference category 64d, sites with drainage areas of less than 100 square miles located in the limestone lowlands of Ecoregion 64 (Figure 8). PCA identifies a subset of 20 water quality parameters that account for most of the variation in the data. Principal components and cluster analyses are presented in Figures 9 and 10.

None of the reference category 64d sample sites approximates the "least disturbed or best attainable" habitat and biological conditions. Each of the sites in reference category 64d has a slightly impaired biological community. Therefore, PENN 50.6, the reference site for reference category 67a (streams with drainage areas of less than 100 square miles in limestone/dolomite valleys) was selected as the reference site for 64d. Excellent habitat is found at two 64d sites; supporting habitat is present at two sites; and partially supporting habitat exists at the remaining five sites. RBP III physical habitat and biological data are summarized in Tables 10 and 11 and Figure 11.

Reference Category 64L

Twenty-two sites within the Northern Piedmont that have drainage areas greater than 100 square miles are included in reference category 64L (Figure 12). PCA identifies a subset of 17 water quality parameters that account for most of the variation in the data. The results of principal components and cluster analyses are presented in Figures 13 and 14.

MDDY 3.3 functions as the reference site for reference category 64L. Eight (36 percent) of the reference category sites are nonimpaired, eight (36 percent) display slight impairment, and four (18 percent) are moderately impaired. Two sites (9 percent) are severely impaired, and sampling produced no macroinvertebrates. Habitat quality is excellent at nine sites, supporting at five sites, partially supporting at six, and two sites have nonsupporting conditions. RBP III physical habitat and biological data are summarized in Tables 12 and 13 and Figure 15.

Reference Category 66

Reference category 66 consists of one site located in the igneous ridges of the Blue Ridge Mountains. Its biological community appears nonimpaired, and its habitat quality is excellent. RBP III physical habitat and biological data are summarized in Tables 14 and 15.

Reference Category 67a

Reference category 67a consists of eight sites that have drainage areas of less than 100 square miles and are located in the limestone/dolomite

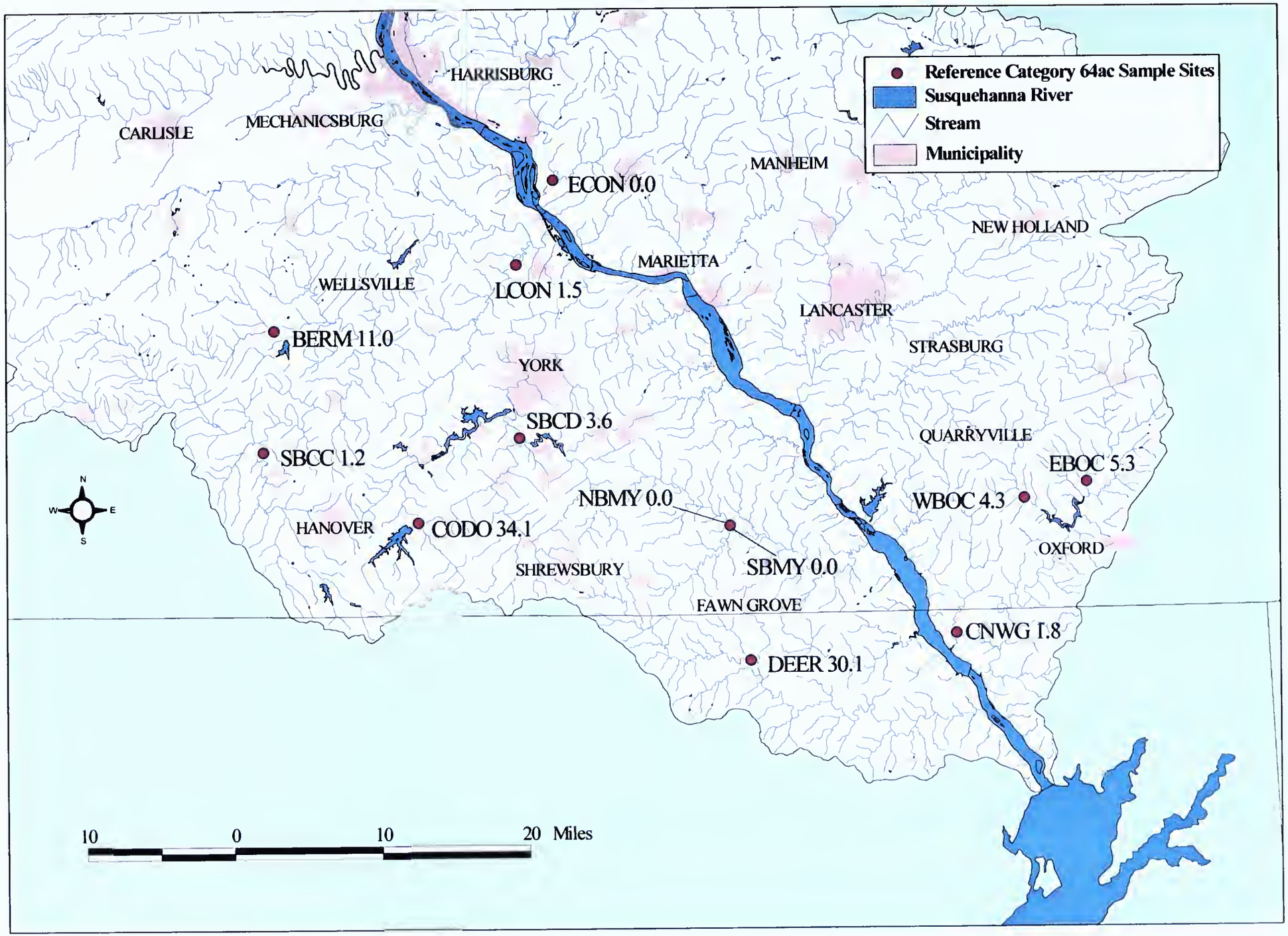


Figure 4. Map of Reference Category 64ac Sample Sites

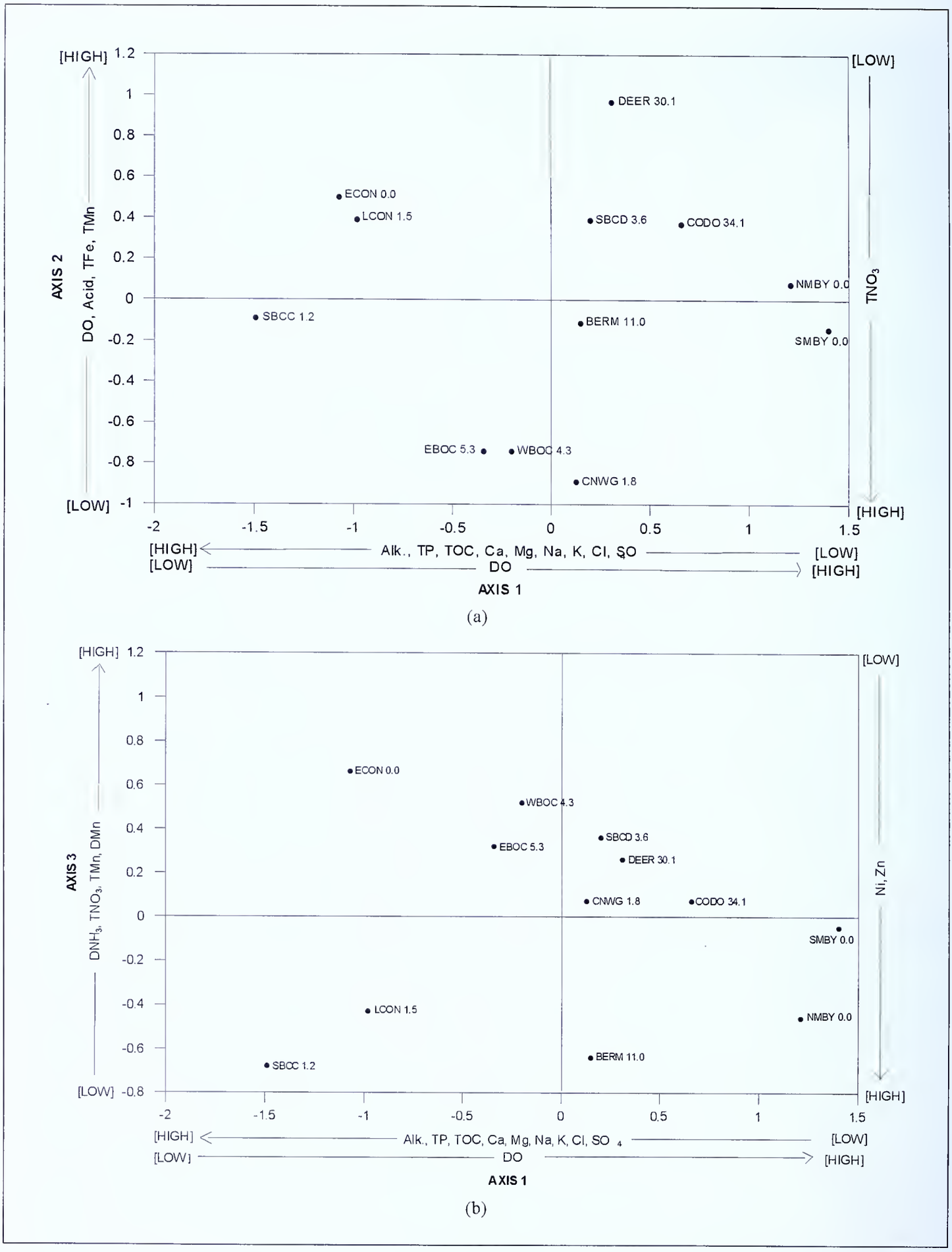
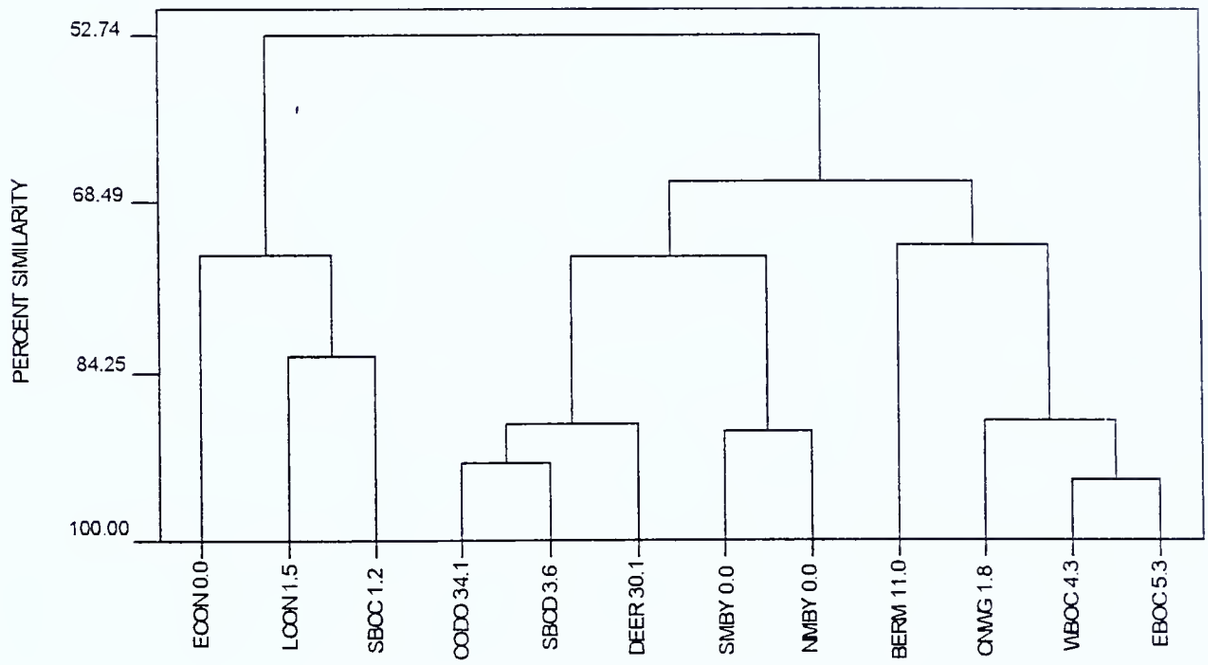


Figure 5. ***Ordination of Reference Category 64ac Sample Sites Based on Principal Components Analysis of Water Quality*** *((a) PCA Axis 1 Versus PCA Axis 2, and (b) PCA Axis 1 Versus PCA Axis 3)*



Water Quality Variables Identified by PCA and Used to Generate Dendrogram

General Variables	Nutrients	Organic Matter	Ions	Metals
DO	TNO_3	TOC	Ca	TFe
Alk	DNH_3		Mg	TMn
Acid	TP		Na	DMn
			K	Ni
			Cl	Zn
			SO_4	

Figure 6. Cluster Analysis of Water Quality Parameters That Account for Most of the Variability in Reference Category 64ac Water Quality Data

Table 8. Summary of Reference Category 64ac RBP III Habitat Data

	SBMY 0.0	BERM 11.0	CNWG 1.8	CODO 34.1	DEER 30.1	EBOC 5.3	ECON 0.0	LCON 1.5	NBMY 0.0	SBCC 1.2	SBCD 3.6	WBOC 4.3
Primary Parameters												
Bottom Substrate	17	15	17	16	17	16	16	17	16	13	6	15
Embeddedness	13	14	11	15	18	14	15	18	15	12	5	15
Velocity/Depth Diversity	18	18	16	17	18	15	15	14	17	17	11	16
Secondary Parameters												
Pool/Riffle Ratio	13	11	12	11	13	13	14	11	12	6	5	14
Pool Quality	13	14	14	10	13	13	14	11	11	11	11	13
Riffle/Run Quality	12	11	11	11	12	14	13	9	13	13	9	11
Channel Alteration	13	9	10	12	11	10	10	11	7	9	6	10
Tertiary Parameters												
Streambank Erosion	5	4	7	9	7	6	5	8	5	7	5	7
Streambank Stability	6	9	6	9	7	6	7	7	9	9	8	8
Streamside Vegetative Cover	7	7	7	9	8	7	7	8	5	7	8	7
Riparian Buffer Zone	5	5	7	8	5	5	4	5	8	2	2	5
Total Habitat Score												
Total Habitat Score	122	117	118	127	129	119	120	119	118	106	76	121
Habitat % of Reference	100	96	97	104	106	98	98	98	97	87	62	99

Table 9. Summary of Reference Category 64ac RBP III Biological Data

	SBMY 0.0	BERM 11.0	CNWG 1.8	CODO 34.1	DEER 30.1	EBOC 5.3	ECON 0.0	LCON 1.5	NBMY 0.0	SBCC 1.2	SBCD 3.6	WBOC 4.3
Raw Data Summary												
Number of Individuals	100	113	100	121	100	100	129	136	114	128	126	129
Percent Shredders	0.0	0.0	2.0	0.8	1.0	2.0	1.6	0.0	0.9	10.9	3.2	2.3
Percent Collector-Gatherers	31.0	11.5	42.0	19.8	20.0	13.0	34.1	15.4	30.7	30.5	26.2	37.2
Percent Filterer-Collectors	20.0	53.1	34.0	30.6	65.0	9.0	15.5	36.0	44.7	20.3	34.1	37.2
Percent Scrapers	33.0	31.9	18.0	43.0	9.0	76.0	46.5	44.1	19.3	35.9	36.5	12.4
Percent Predators	16.0	3.5	4.0	5.8	5.0	0.0	2.3	4.4	4.4	2.3	0.0	10.9
Number of EPT Taxa	13	6	6	10	10	5	7	8	10	6	8	10
Number of EPT Individuals	70	67	71	54	82	24	92	54	86	52	90	90
Metric Scores												
Taxonomic Richness	19	14	13	17	15	9	17	20	16	16	17	17
Diversity Index	3.80	3.07	2.96	3.42	3.24	2.17	3.18	3.65	3.36	3.26	3.14	3.49
Hilsenhoff Biotic Index	3.78	4.58	4.87	4.61	4.00	4.35	4.55	4.68	3.83	5.43	4.52	4.46
EPT Index	13	6	6	10	10	5	7	8	10	6	8	10
Taxonomic Similarity (%)	100.0	42.3	50.0	39.8	43.0	39.0	41.1	52.5	55.1	45.6	55.8	50.7
Trophic Similarity (%)	100.0	66.9	73.0	78.6	54.0	55.0	81.8	72.9	74.4	85.8	79.2	74.3
Percent of Reference												
Taxonomic Richness	100.0	73.7	68.4	89.5	78.9	47.4	89.5	105.3	84.2	84.2	89.5	89.5
Diversity Index	100.0	80.8	77.9	90.0	85.3	57.1	83.7	96.1	88.4	85.8	82.6	91.8
Hilsenhoff Biotic Index	100.0	82.5	77.6	82.0	94.5	86.9	83.1	80.8	98.6	69.6	83.7	84.8
EPT Index	100.0	46.2	46.2	76.9	76.9	38.5	53.8	61.5	76.9	46.2	61.5	76.9
Taxonomic Similarity (%)	100.0	42.3	50.0	39.8	43.0	39.0	41.1	52.5	55.1	45.6	55.8	50.7
Trophic Similarity (%)	100.0	66.9	73.0	78.6	54.0	55.0	81.8	72.9	74.4	85.8	79.2	74.3
Biological Condition Scores												
Taxonomic Richness	6	4	4	6	4	2	6	6	6	6	6	6
Diversity Index	6	6	6	6	6	4	6	6	6	6	6	6
Hilsenhoff Biotic Index	6	4	4	4	6	6	4	4	6	2	4	4
EPT Index	6	0	0	2	2	0	0	0	2	0	0	2
Taxonomic Similarity (%)	6	4	6	4	4	4	4	6	6	6	6	6
Trophic Similarity (%)	6	4	4	6	4	4	6	4	4	6	6	4
Total Biological Score												
Total Biological Score	36	22	24	28	26	20	26	26	30	26	28	28
Biological %of Reference	100	61	67	78	72	56	72	72	83	72	78	78

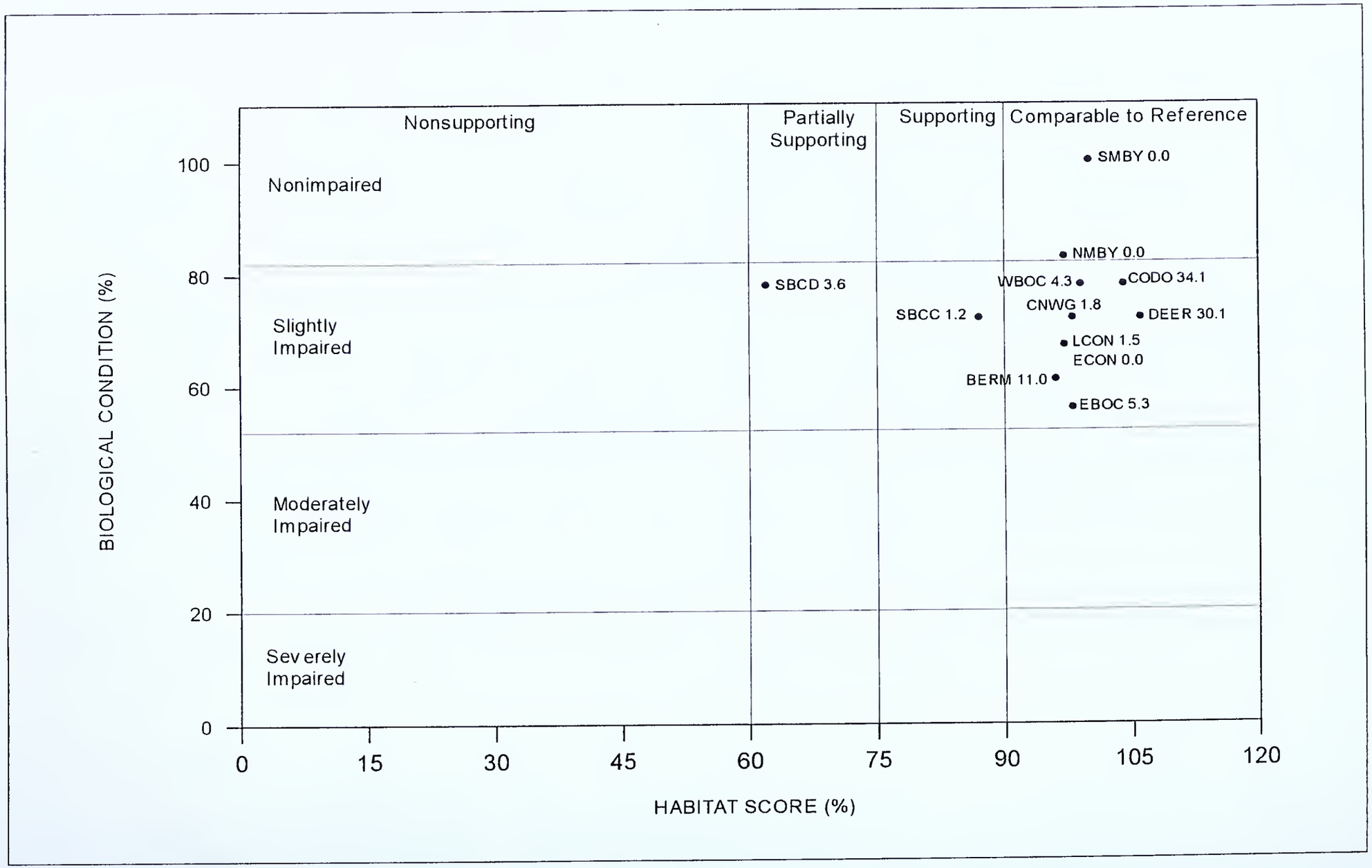


Figure 7. Summary of Reference Category 64ac RBP III Biological and Habitat Data

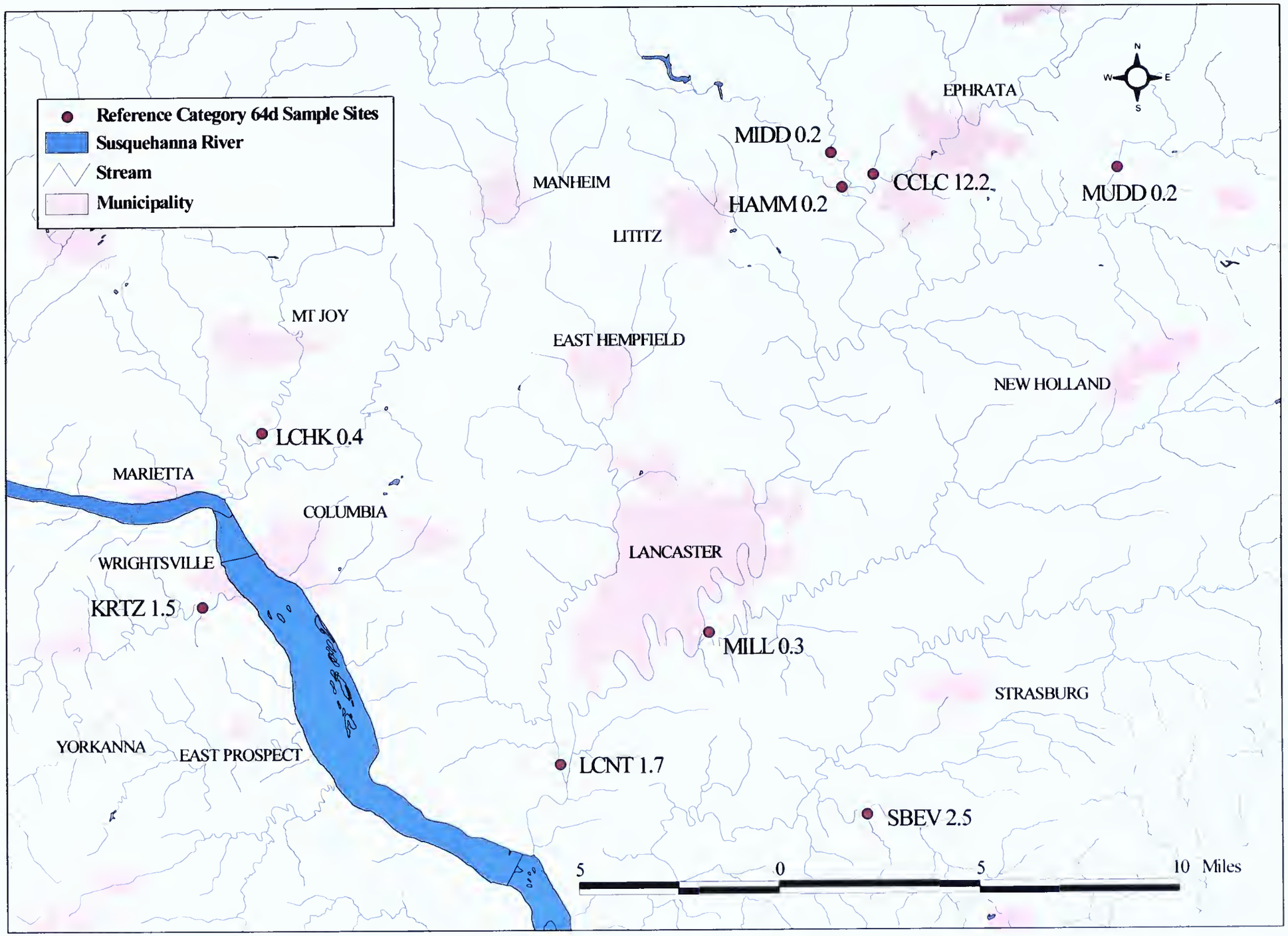


Figure 8. Map of Reference Category 64d Sample Sites

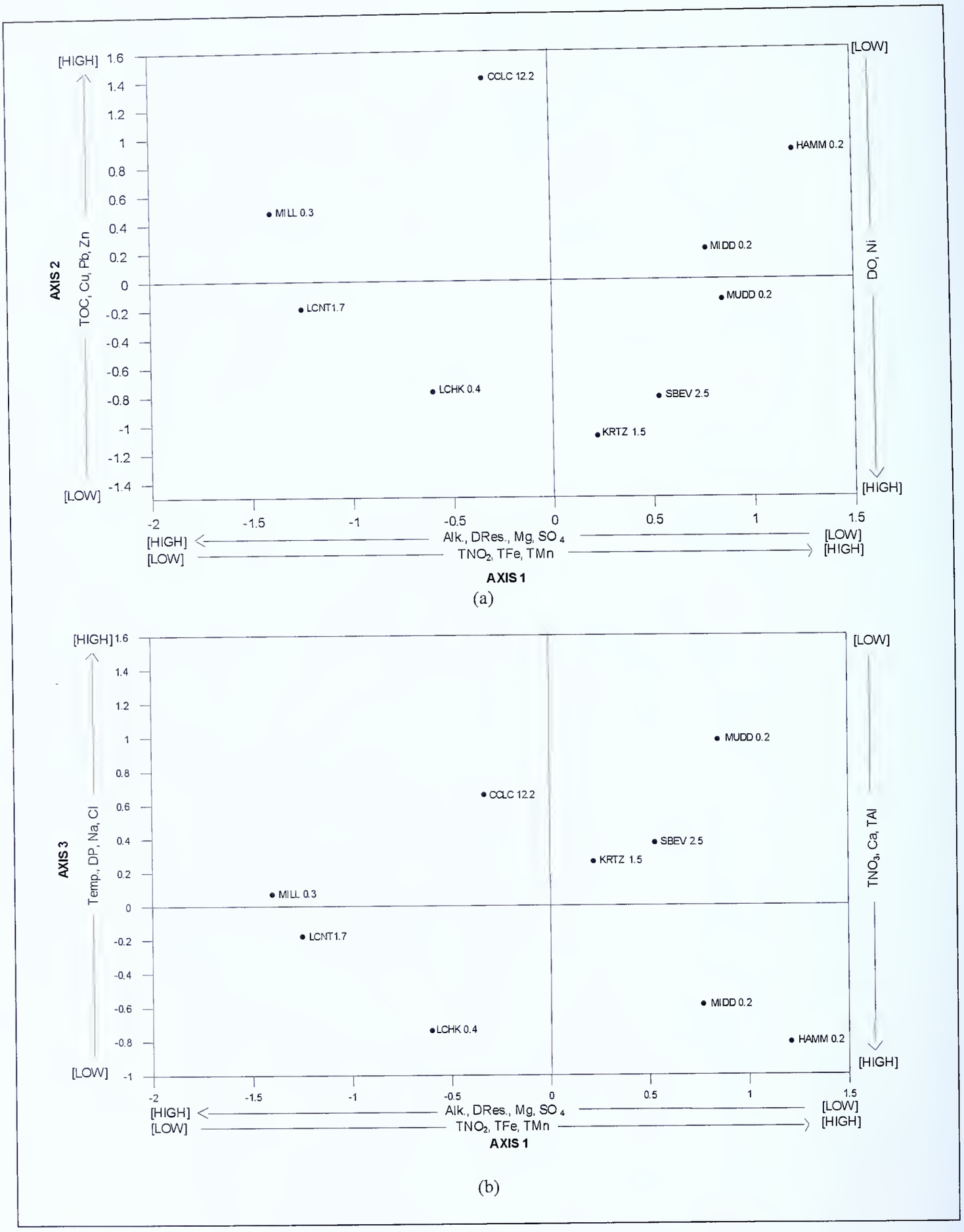
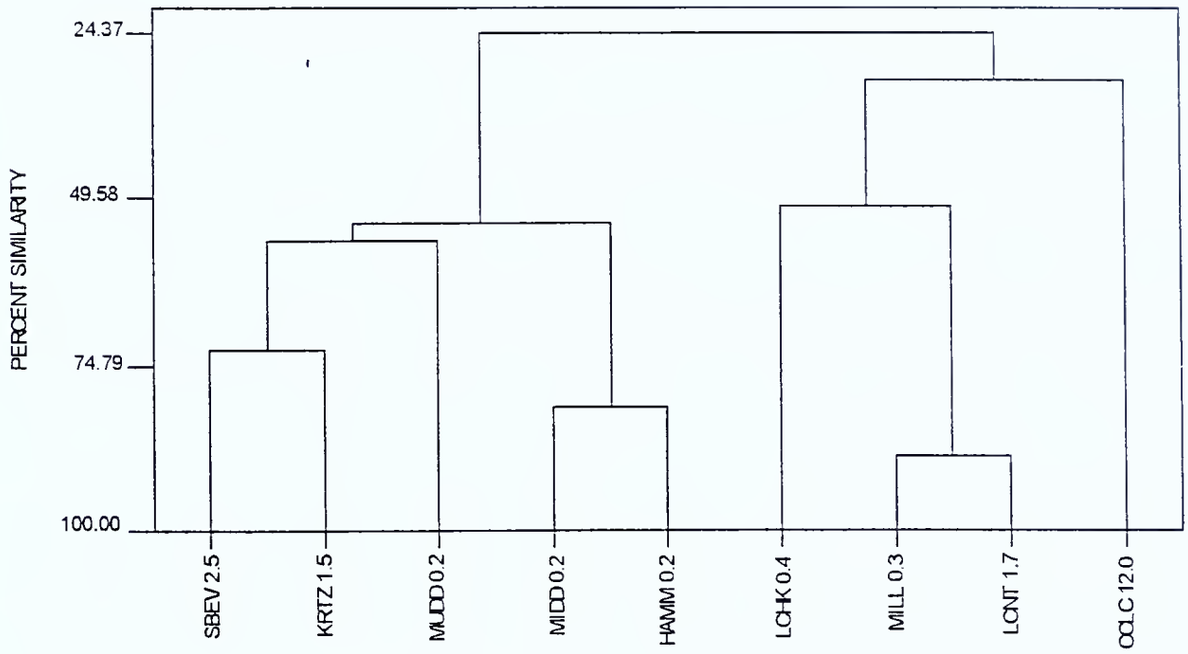


Figure 9. ***Ordinations of Reference Category 64d Sample Sites Based on Principal Components Analysis of Water Quality*** *((a) PCA Axis 1 Versus PCA Axis 2, and (b) PCA Axis 1 Versus PCA Axis 3)*



Water Quality Variables Identified by PCA and Used to Generate Dendrogram

General Variables	Nutrients	Organic Matter	Ions	Metals
Temp	TNO_3	TOC	Ca	Cu
DO	TNO_2		Mg	TFe
Alk	DP		Na	Pb
DRes			Cl	TMn
			SO_4	Ni
				Zn
				TAl

Figure 10. Cluster Analysis of Water Quality Parameters That Account for Most of the Variability in Reference Category 64d Water Quality Data

Table 10. Summary of Reference Category 64d RBP III Habitat Data

	CLLC 12.2	HAMM 0.2	KRTZ 1.5	LCHK 0.4	LCNT 1.7	MIDD 0.2	MILL 0.3	MUDD 0.2	SBEV 2.5
Primary Parameters									
Bottom Substrate	11	9	13	8	15	11	18	11	17
Embeddedness	15	10	8	10	16	10	17	10	15
Velocity/Depth Diversity	16	16	15	14	17	14	17	11	16
Secondary Parameters									
Pool/Riffle Ratio	12	12	6	6	11	13	13	6	13
Pool Quality	11	12	10	11	10	13	11	12	12
Riffle/Run Quality	9	7	12	10	13	6	11	10	8
Channel Alteration	8	5	6	7	11	7	12	6	10
Tertiary Parameters									
Streambank Erosion	7	5	5	7	5	5	5	5	8
Streambank Stability	9	4	8	5	5	5	8	5	8
Streamside Vegetative Cover	6	6	5	6	6	6	7	6	7
Riparian Buffer Zone	4	3	3	3	5	4	4	4	5
Total Habitat Score									
Total Habitat Score	108	89	91	87	114	94	123	86	119
Habitat % of Reference	82	67	69	66	86	71	93	65	90

Table 11. Summary of Reference Category 64d RBP III Biological Data

	CCLC 12.2	HAMM 0.2	KRTZ 1.5	LCHK 0.4	LCNT 1.7	MIDD 0.2	MILL 0.3	MUDD 0.2	SBEV 2.5
Raw Data Summary									
Number of Individuals	100	98	100	125	120	55	100	104	225
Percent Shredders	2.0	1.0	1.0	1.6	0.0	12.7	0.0	0.0	0.0
Percent Collector-Gatherers	5.0	42.9	20.0	12.0	25.8	67.3	6.0	22.1	21.3
Percent Filterer-Collectors	60.0	6.1	56.0	28.8	24.2	7.3	33.0	18.3	48.9
Percent Scrapers	33.0	49.0	10.0	56.8	46.7	12.7	59.0	53.8	28.9
Percent Predators	0.0	1.0	13.0	0.8	3.3	0.0	2.0	5.8	0.9
Number of EPT Taxa	5	6	6	6	6	6	8	5	7
Number of EPT Individuals	47	49	62	45	49	10	43	21	144
Metric Scores									
Taxonomic Richness	11	14	14	13	14	13	13	12	14
Diversity Index	2.58	2.52	3.33	2.43	2.80	2.55	2.55	2.29	2.44
Hilsenhoff Biotic Index	4.86	5.16	4.75	4.84	5.01	5.73	4.62	5.11	4.73
EPT Index	5	6	6	6	6	6	8	5	7
Taxonomic Similarity (%)	37.8	21.2	30.3	25.9	42.6	32.1	11.8	19.8	20.4
Trophic Similarity (%)	67.9	43.7	84.8	51.2	60.9	51.5	49.0	51.3	79.1
Percent of Reference									
Taxonomic Richness	57.9	73.7	73.7	68.4	73.7	68.4	68.4	63.2	73.7
Diversity Index	97.0	94.7	125.2	91.4	105.3	95.9	95.9	86.1	91.7
Hilsenhoff Biotic Index	96.3	90.7	98.6	96.7	93.5	81.7	101.3	91.7	98.9
EPT Index	50.0	60.0	60.0	60.0	60.0	60.0	80.0	50.0	70.0
Taxonomic Similarity (%)	37.8	21.2	30.3	25.9	42.6	32.1	11.8	19.8	20.4
Trophic Similarity (%)	67.9	43.7	84.8	51.2	60.9	51.5	49.0	51.3	79.1
Biological Condition Scores									
Taxonomic Richness	2	4	4	4	4	4	4	4	4
Diversity Index	6	6	6	6	6	6	6	6	6
Hilsenhoff Biotic Index	6	6	6	6	6	4	6	6	6
EPT Index	0	0	0	0	0	0	4	0	2
Taxonomic Similarity (%)	4	2	2	2	4	2	0	0	2
Trophic Similarity (%)	4	2	6	4	4	4	2	4	6
Total Biological Score									
Total Biological Score	22	20	24	22	24	20	22	20	26
Biological % of Reference	61	56	67	61	67	56	61	56	72

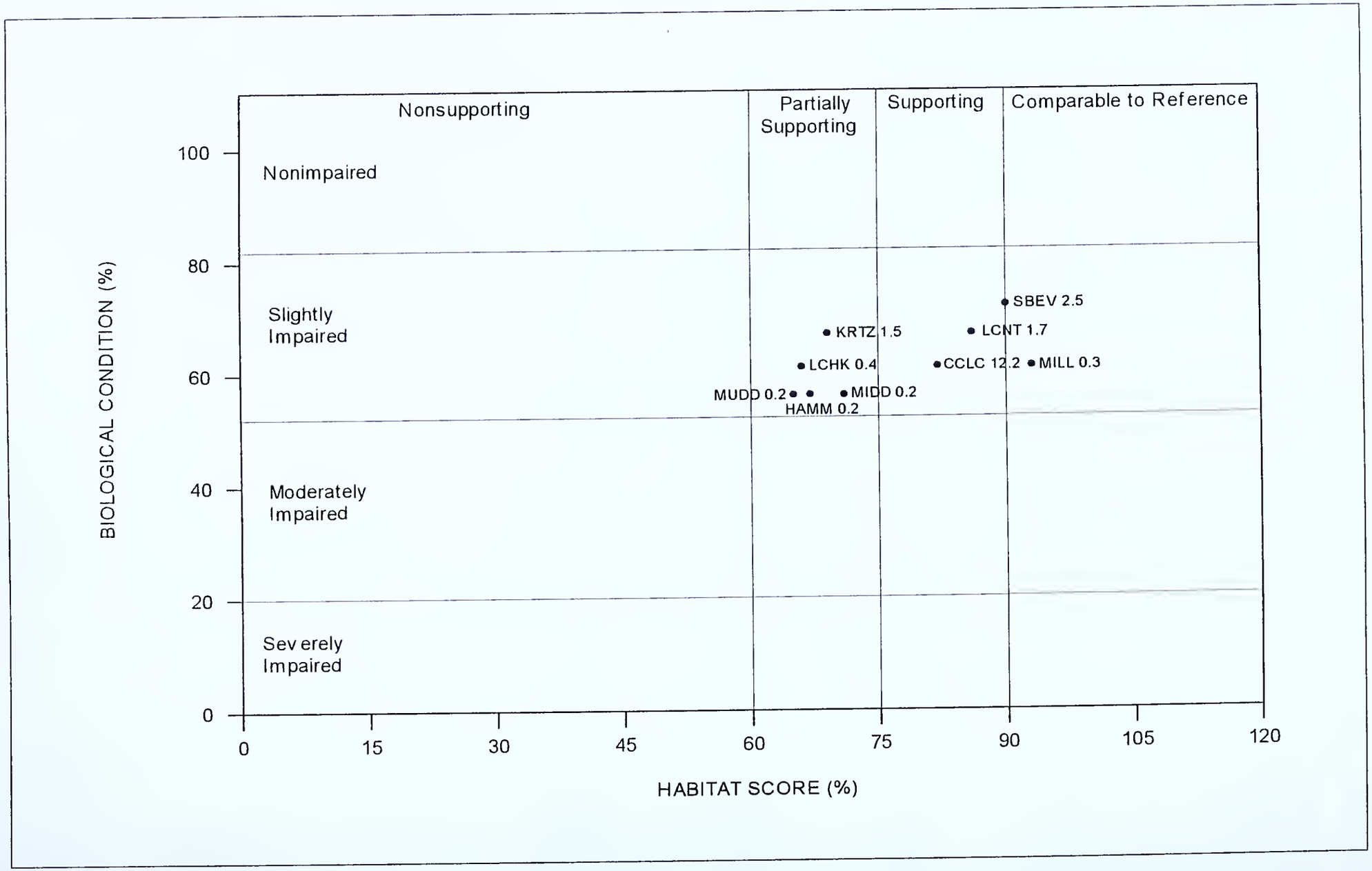


Figure 11. Summary of Reference Category 64d RBP III Biological and Habitat Data

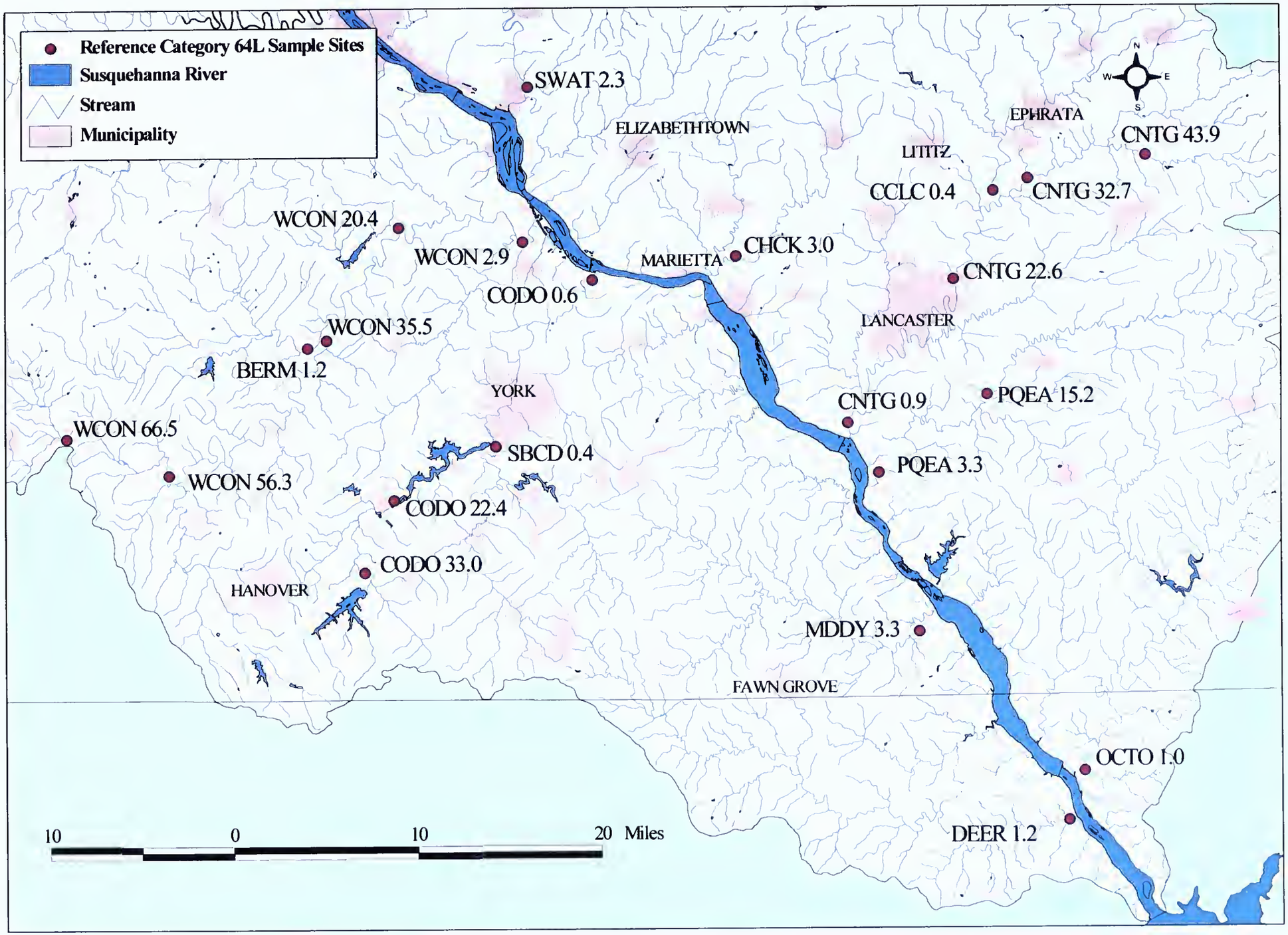


Figure 12. Map of Reference Category 64L Sample Sites

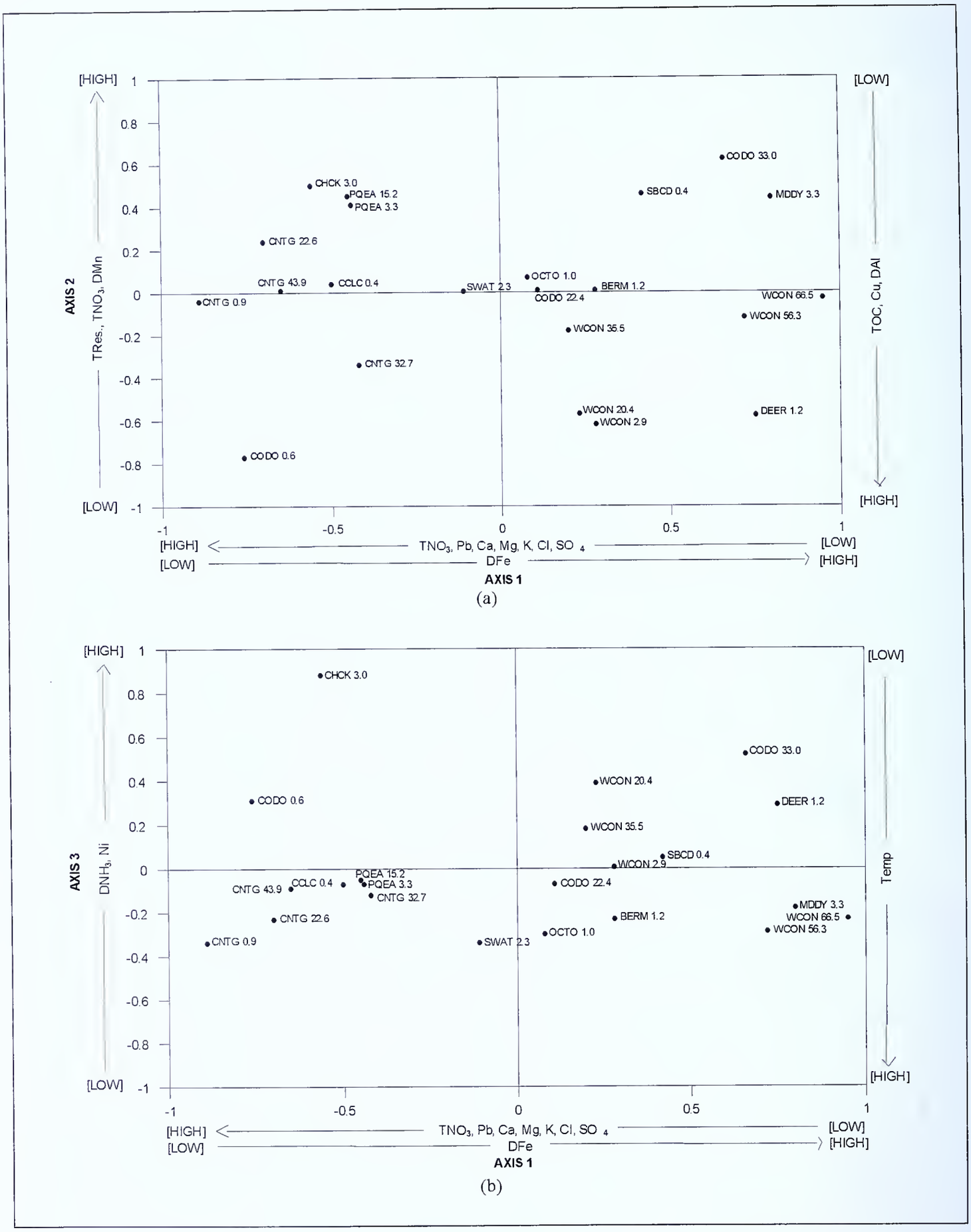
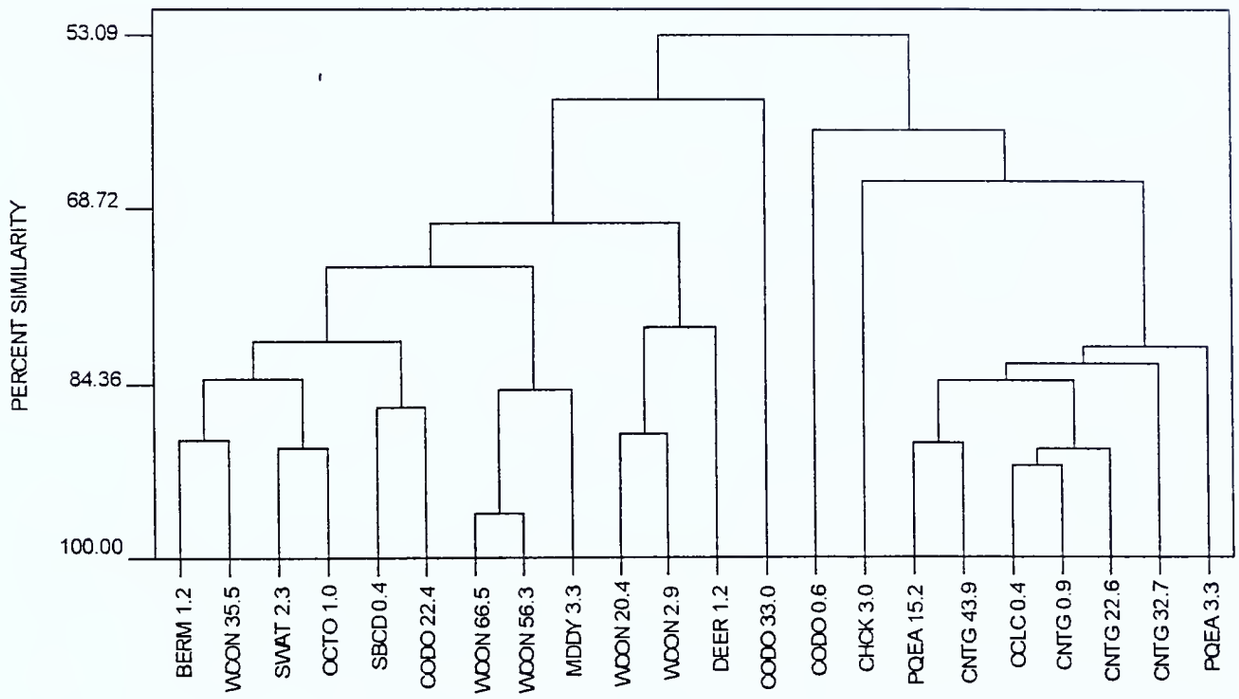


Figure 13. Ordinations of Reference Category 64L Sample Sites Based on Principal Components Analysis of Water Quality ((a) PCA Axis 1 Versus PCA Axis 2, and (b) PCA Axis 1 Versus PCA Axis 3)



Water Quality Variables Identified by PCA and Used to Generate Dendrogram

General Variables	Nutrients	Organic Matter	Ions	Metals
Temp	TNO_3	TOC	Ca	DAl
TRes	DNH_3		Mg	Ni
			Na	DMn
			K	Pb
			Cl	DFe
			SO_4	Cu

Figure 14. Cluster Analysis of Water Quality Parameters That Account for Most of the Variability in Reference Category 64L Water Quality Data

Table 12. Summary of Reference Category 64L RBP III Habitat Data

	MDDY 3.3	BERM 1.2	CHCK 3.0	CLLC 0.4	CNTG 0.9	CNTG 22.6	CNTG 32.7	CNTG 43.9	CODO 0.6	CODO 22.4	CODO 33.0
Primary Parameters											
Bottom Substrate	18	18	14	12	17	7	7	9	17	3	18
Embeddedness	17	18	11	12	16	15	11	11	18	4	18
Velocity/Depth Diversity	17	17	15	16	17	10	16	13	17	7	17
Secondary Parameters											
Pool/Riffle Ratio	13	13	12	8	10	5	5	10	9	3	13
Pool Quality	11	11	11	12	13	12	11	9	13	11	13
Riffle/Run Quality	13	10	12	10	11	11	10	8	13	7	13
Channel Alteration	12	13	7	10	11	3	7	8	12	9	12
Tertiary Parameters											
Streambank Erosion	5	7	6	7	5	2	7	9	6	4	7
Streambank Stability	6	9	5	7	6	9	6	7	8	5	9
Streamside Vegetative Cover	7	9	7	6	7	5	7	5	9	2	8
Riparian Buffer Zone	8	5	5	4	4	4	4	3	8	2	6
Total Habitat Score											
Total Habitat Score	127	130	105	104	117	83	91	92	130	57	134
Habitat % of Reference	100	102	83	82	92	65	72	72	102	45	106

	DEER 1.2	OCTO 1.0	PQEA 15.2	PQEA 3.3	SBCD 0.4	SWAT 2.3	WCON 2.9	WCON 20.4	WCON 35.5	WCON 56.3	WCON 66.5
Primary Parameters											
Bottom Substrate	9	16	10	8	15	17	17	12	4	17	18
Embeddedness	17	14	8	7	13	12	17	11	4	14	17
Velocity/Depth Diversity	16	16	11	10	17	17	18	8	3	17	10
Secondary Parameters											
Pool/Riffle Ratio	12	11	7	8	11	6	7	3	3	8	8
Pool Quality	11	12	9	9	10	13	12	9	12	9	12
Riffle/Run Quality	11	12	7	7	10	13	12	6	10	13	10
Channel Alteration	7	7	8	6	13	7	11	12	13	13	12
Tertiary Parameters											
Streambank Erosion	4	6	5	5	5	5	7	4	4	7	7
Streambank Stability	6	6	5	6	8	8	6	7	6	9	9
Streamside Vegetative Cover	7	5	6	7	9	7	7	4	7	5	7
Riparian Buffer Zone	5	4	4	4	5	4	2	4	5	8	5
Total Habitat Score											
Total Habitat Score	105	109	80	77	116	109	116	80	71	120	115
Habitat % of Reference	83	86	63	61	91	86	91	63	56	94	91

Table 13. Summary of Reference Category 64L RBP III Biological Data

	MDDY 3.3	BERM 1.2	CCLC 0.4	CHCK 3.0	CNTG 0.9	CNTG 22.6	CNTG 32.7	CNTG 43.9	CODO 0.6	CODO 33.0
Raw Data Summary										
Number of Individuals	101	100	112	102	114	100	119	111	101	133
Percent Shredders	2.0	0.0	4.5	5.9	0.0	3.0	1.7	0.0	31.7	30.8
Percent Collector-Gatherers	39.6	25.0	7.1	5.9	5.3	27.0	4.2	12.6	7.9	12.8
Percent Filterer-Collectors	36.6	26.0	30.4	16.7	57.0	11.0	5.9	52.3	4.0	27.1
Percent Scrapers	5.0	45.0	57.1	70.6	36.8	55.0	85.7	34.2	55.4	3.0
Percent Predators	16.8	4.0	0.9	1.0	0.9	4.0	2.5	0.9	1.0	26.3
Number of EPT Taxa	11	11	5	6	5	8	4	6	5	-5
Number of EPT Individuals	85	65	26	29	78	58	5	60	19	49
Metric Scores										
Taxonomic Richness	16	15	14	12	12	15	16	13	12	11
Diversity Index	3.37	3.48	2.52	2.39	2.65	3.14	1.69	3.00	2.55	2.59
Hilsenhoff Biotic Index	4.32	4.23	5.00	4.60	4.60	4.92	5.11	4.98	5.32	5.80
EPT Index	11	11	5	6	5	8	4	6	5	5
Taxonomic Similarity (%)	100.0	37.8	31.9	16.8	26.1	12.9	8.2	37.7	9.9	14.5
Trophic Similarity (%)	100.0	60.0	45.3	30.5	47.7	48.9	19.2	55.1	19.8	61.7
Percent of Reference										
Taxonomic Richness	100.0	93.8	87.5	75.0	75.0	93.8	100.0	81.3	75.0	68.8
Diversity Index	100.0	103.3	74.8	70.9	78.6	93.2	50.1	89.0	75.7	76.9
Hilsenhoff Biotic Index	100.0	102.1	86.3	93.9	93.9	87.7	84.5	86.6	81.2	74.4
EPT Index	100.0	100.0	45.5	54.5	45.5	72.7	36.4	54.5	45.5	45.5
Taxonomic Similarity (%)	100.0	37.8	31.9	16.8	26.1	12.9	8.2	37.7	9.9	14.5
Trophic Similarity (%)	100.0	60.0	45.3	30.5	47.7	48.9	19.2	55.1	19.8	61.7
Biological Condition Scores										
Taxonomic Richness	6	6	6	4	4	6	6	6	4	4
Diversity Index	6	6	4	4	6	6	4	6	6	6
Hilsenhoff Biotic Index	6	6	6	6	6	6	4	6	4	4
EPT Index	6	6	0	0	0	2	0	0	0	0
Taxonomic Similarity (%)	6	4	2	0	2	0	0	4	0	0
Trophic Similarity (%)	6	4	2	2	2	2	0	4	0	4
Total Biological Score										
Total Biological Score	36	32	20	16	20	22	14	26	14	18
Biological % of Reference	100	89	56	44	56	61	39	72	39	50

Table 13. Summary of Reference Category 64L RBP III Biological Data—Continued

	DEER 1.2	OCTO 1.0	PQEA 15.2	PQEA 3.3	SBCD 0.4	SWAT 2.3	WCON 2.9	WCON 20.4	WCON 56.3	WCON 66.5
Raw Data Summary										
Number of Individuals	119	100	124	114	113	111	183	100	130	130
Percent Shredders	29.4	2.0	1.6	1.8	0.9	0.0	0.0	2.0	1.5	4.6
Percent Collector-Gatherers	37.0	35.0	8.9	9.6	11.5	27.9	15.8	13.0	20.0	32.3
Percent Filterer-Collectors	19.3	22.0	46.0	14.9	45.1	26.1	54.6	74.0	36.2	4.6
Percent Scrapers	8.4	40.0	43.5	72.8	38.1	45.9	26.2	7.0	41.5	51.5
Percent Predators	5.9	1.0	0.0	0.9	4.4	0.0	3.3	4.0	0.8	6.9
Number of EPT Taxa	11	7	6	6	8	10	10	10	9	8
Number of EPT Individuals	66	62	73	47	99	38	143	43	62	46
Metric Scores										
Taxonomic Richness	19	14	11	15	15	16	17	17	15	16
Diversity Index	3.03	2.92	2.64	2.65	3.00	3.51	3.24	3.01	3.09	3.45
Hilsenhoff Biotic Index	5.29	4.86	4.65	4.47	3.75	5.00	4.17	5.20	4.68	4.85
EPT Index	11	7	6	6	8	10	10	10	9	8
Taxonomic Similarity (%)	41.8	38.8	26.7	22.3	45.8	33.0	40.9	41.8	43.3	17.3
Trophic Similarity (%)	69.1	64.9	52.1	32.1	58.4	59.0	60.7	60.6	63.4	50.8
Percent of Reference										
Taxonomic Richness	118.8	87.5	68.8	93.8	93.8	100.0	106.3	106.3	93.8	100.0
Diversity Index	89.9	86.6	78.3	78.6	89.0	104.2	96.1	89.3	91.7	102.4
Hilsenhoff Biotic Index	81.5	88.8	92.8	96.5	115.0	86.3	103.4	83.0	92.1	89.1
EPT Index	100.0	63.6	54.5	54.5	72.7	90.9	90.9	90.9	81.8	72.7
Taxonomic Similarity (%)	41.8	38.8	26.7	22.3	45.8	33.0	40.9	41.8	43.3	17.3
Trophic Similarity (%)	69.1	64.9	52.1	32.1	58.4	59.0	60.7	60.6	63.4	50.8
Biological Condition Scores										
Taxonomic Richness	6	6	4	6	6	6	6	6	6	6
Diversity Index	6	6	6	6	6	6	6	6	6	6
Hilsenhoff Biotic Index	4	6	6	6	6	6	6	4	6	6
EPT Index	6	0	0	0	2	6	6	6	4	2
Taxonomic Similarity (%)	4	4	2	2	6	4	4	4	4	0
Trophic Similarity (%)	4	4	4	2	4	4	4	4	4	4
Total Biological Score										
Total Biological Score	30	26	22	22	30	32	32	30	30	24
Biological % of Reference	83	72	61	61	83	89	89	83	83	67

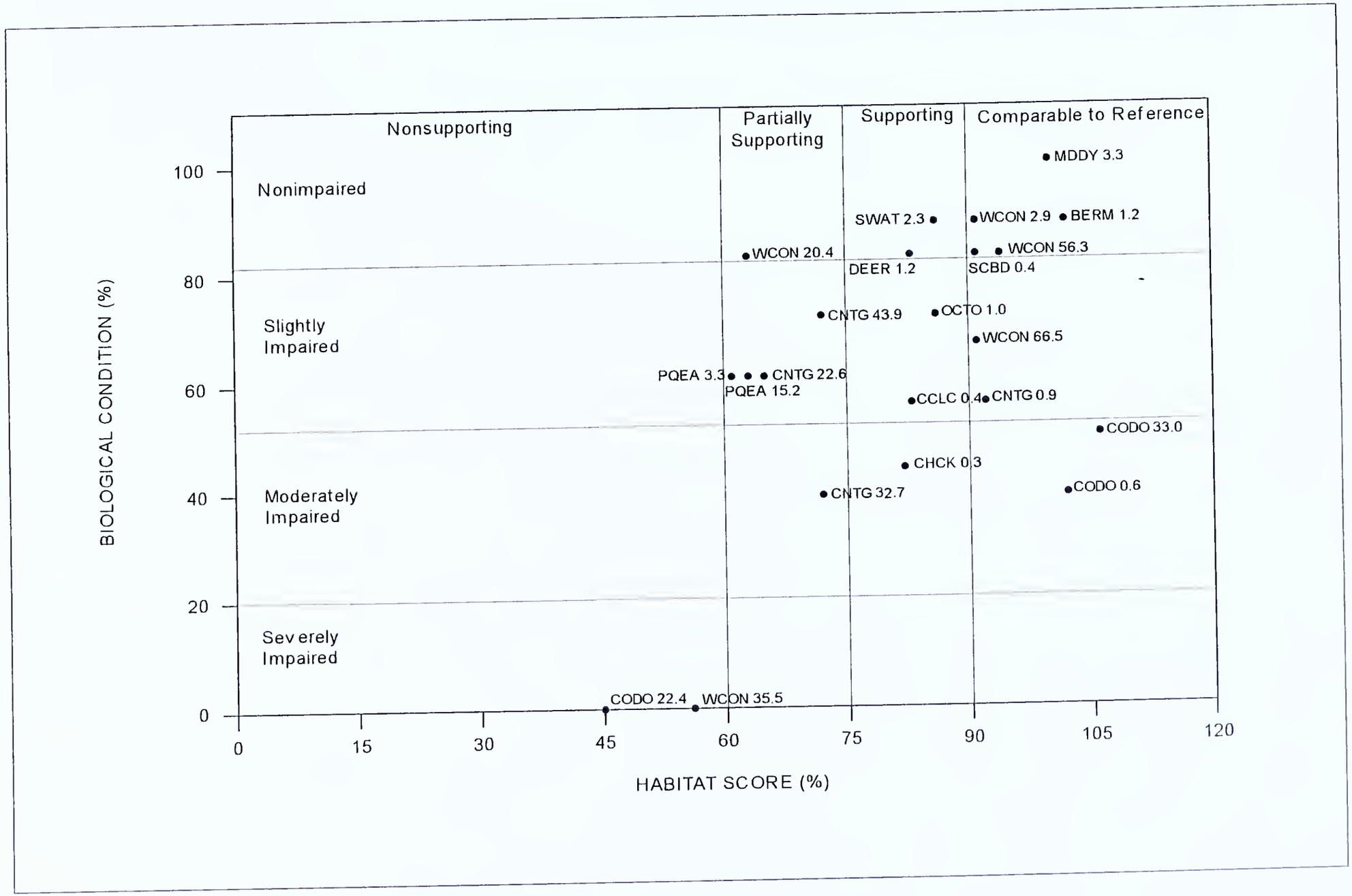


Figure 15. Summary of Reference Category 64L RBP III Biological and Habitat Data

Table 14. Summary of Reference Category 66 and 67a RBP III Habitat Data

Reference Category 66		Reference Category 67a							
	MNTN 3.0	PENN 50.6	BEAV 0.6	ELKN 0.1	LTRT 0.1	MISP 0.5	SPRG 0.0	TRDL 0.0	WPIN 0.8
Primary Parameters									
Bottom Substrate	18	18	15	18	18	18	14	18	8
Embeddedness	17	16	7	18	12	11	13	15	12
Velocity/Depth Diversity	15	18	14	20	17	16	15	18	8
Secondary Parameters									
Pool/Riffle Ratio	13	13	11	12	14	12	12	13	13
Pool Quality	12	14	10	14	11	10	8	11	10
Riffle/Run Quality	11	14	11	14	13	12	12	13	10
Channel Alteration	13	12	9	13	13	10	12	13	12
Tertiary Parameters									
Streambank Erosion	7	9	5	7	7	7	3	7	9
Streambank Stability	9	7	6	7	9	9	5	7	9
Streamside Vegetative Cover	7	7	7	8	7	9	6	9	10
Riparian Buffer Zone	2	4	6	4	2	5	7	4	4
Total Habitat Score									
Total Habitat Score	124	132	101	135	123	119	107	128	105
Habitat % of Reference		100	77	102	93	90	81	97	80

Table 15. Summary of Reference Category 66 and 67a RBP III Biological Data

Reference Category 66		Reference Category 67a							
	MNTN 3.0	PENN 50.6	BEAV 0.6	ELKN 0.1	LTRT 0.1	MISP 0.5	SPRG 0.0	TRDL 0.0	WPIN 0.8
Raw Data Summary									
Number of Individuals	136	138	125	184	190	128	108	142	232
Percent Shredders	15.4	8.7	1.6	0.5	52.6	4.7	12.0	76.1	2.6
Percent Collector-Gatherers	30.1	27.5	13.6	65.8	15.3	41.4	13.9	23.2	78.0
Percent Filterer-Collectors	16.9	52.9	20.8	22.8	24.2	28.1	0.9	0.7	1.7
Percent Scrapers	20.6	8.0	64.0	9.8	7.4	25.0	73.1	0.0	13.8
Percent Predators	16.9	2.9	0.0	1.1	0.5	0.8	0.0	0.0	3.9
Number of EPT Taxa	16	10	6	15	4	7	2	0	6
Number of EPT Individuals	95	94	24	62	47	48	12	0	24
Metric Scores									
Taxonomic Richness	25	19	13	21	14	18	10	4	15
Diversity Index	4.08	2.66	2.94	2.58	2.75	3.34	1.69	0.98	1.41
Hilsenhoff Biotic Index	3.60	4.68	4.70	5.83	5.43	5.36	5.20	6.27	6.10
EPT Index	16	10	6	15	4	7	2	0	6
Taxonomic Similarity (%)		100.0	24.3	36.4	17.7	45.9	14.6	18.6	15.7
Trophic Similarity (%)		100.0	43.9	60.0	56.1	69.1	31.5	32.6	42.7
Percent of Reference									
Taxonomic Richness		100.0	68.4	110.5	73.7	94.7	52.6	21.1	78.9
Diversity Index		100.0	110.5	97.0	103.4	125.6	63.5	36.8	53.0
Hilsenhoff Biotic Index		100.0	99.7	80.3	86.3	87.3	90.0	74.6	76.8
EPT Index		100.0	60.0	150.0	40.0	70.0	20.0	0.0	60.0
Taxonomic Similarity (%)		100.0	24.3	36.4	17.7	45.9	14.6	18.6	15.7
Trophic Similarity (%)		100.0	43.9	60.0	56.1	69.1	31.5	32.6	42.7
Biological Condition Scores									
Taxonomic Richness		6	4	6	4	6	2	0	4
Diversity Index		6	6	6	6	6	4	2	4
Hilsenhoff Biotic Index		6	6	4	6	6	6	4	4
EPT Index		6	0	6	0	2	0	0	0
Taxonomic Similarity (%)		6	2	4	0	6	0	0	0
Trophic Similarity (%)		6	2	4	4	4	2	2	2
Total Biological Score									
Total Biological Score		36	20	30	20	30	14	8	14
Biological % of Reference		100	56	83	56	83	39	22	39

valleys of the Central Appalachian Ridge and Valley Ecoregion (Figure 16). PCA identified a subset of 18 water quality parameters that account for most of the variation in the data. Figures 17 and 18 present the results of principal components and cluster analyses.

PENN 50.6 is the reference site for reference category 67a. Reference category 67a includes three sites (37.5 percent) that support nonimpaired biological communities. Of the remaining five sites, two (25 percent) show slight impairment, and three (37.5 percent) are moderately impaired. Five of the sites have excellent habitat; three have supporting conditions. RBP III physical habitat and biological data are summarized in Tables 14 and 15 (pages 38 and 39) and Figure 19.

Reference Category 67b

Sixteen sample sites are included in reference category 67b, sites with drainage areas of less than 100 square miles located in the shale or slate non-calcareous valleys of Ecoregion 67 (Figure 20). PCA identifies a subset of 18 water quality parameters that account for most of the variation in the data. The results of principal components and cluster analyses are presented in Figures 21and 22, respectively.

The reference category 67b reference site is WHMT 2.2. The biological communities of three (19 percent) reference category 67b sites are nonimpaired, five (31 percent) are slightly impaired, and seven (44 percent) are moderately impaired. The biological community of one site (6 percent) is severely impaired and has nonsupporting habitat conditions. Habitat conditions are classified as excellent at ten sites and supporting at five sites. RBP III physical habitat and biological data are summarized in Tables 16 and 17 and Figure 23.

Reference Category 67cd

Six sample sites are included in reference category 67cd. These sites have drainage areas of less than 100 square miles and are located in the shale or sandstone ridge subregions of Ecoregion 67 (Figure 24). PCA identifies a subset of 19 water quality parameters that account for most of the variation in the water quality data. The results of principal components and cluster analyses are presented in Figures 25 and 26, respectively.

STON 0.4 is the reference site for reference category 67cd. The biological communities of half of the sites are nonimpaired. The remaining communities are slightly impaired. One site in 67cd has supporting habitat conditions; all others are excellent. RBP III physical habitat and biological data are summarized in Tables 18 and 19 and Figure 27.

Reference Category 67L

Reference category 67L consists of 16 sites located in Ecoregion 67 that have drainage areas of greater than 100 square miles (Figure 28). PCA identified a subset of 17 water quality parameters that account for most of the variation in the data. The results of principal components and cluster analyses are presented in Figures 29 and 30, respectively.

PENN 30.0 functions as the reference site for reference category 67L. Of the 16 sites, four (27 percent) support nonimpaired communities, seven (47 percent) are slightly impaired, and three (20 percent) are moderately impaired. Sampling at one site produced no macroinvertebrates, and is thus classified as severely impaired, and high water conditions precluded sampling at SWAT 21.7. Habitat conditions are excellent at six of the sites, supporting at seven, partially supporting at two, and nonsupporting at one. RBP III physical habit and biological data are summarized in Tables 20 and 21 and Figure 31.

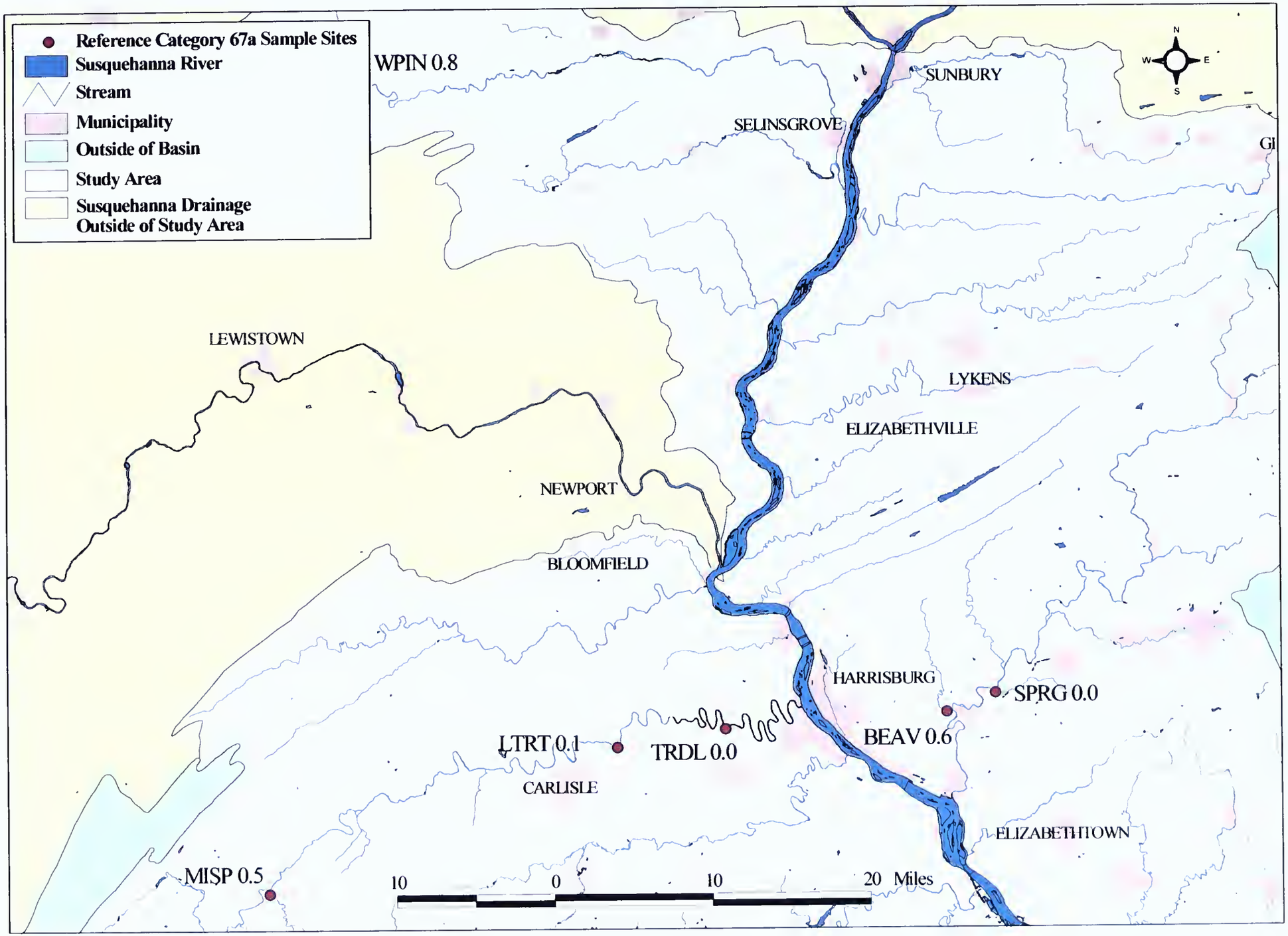
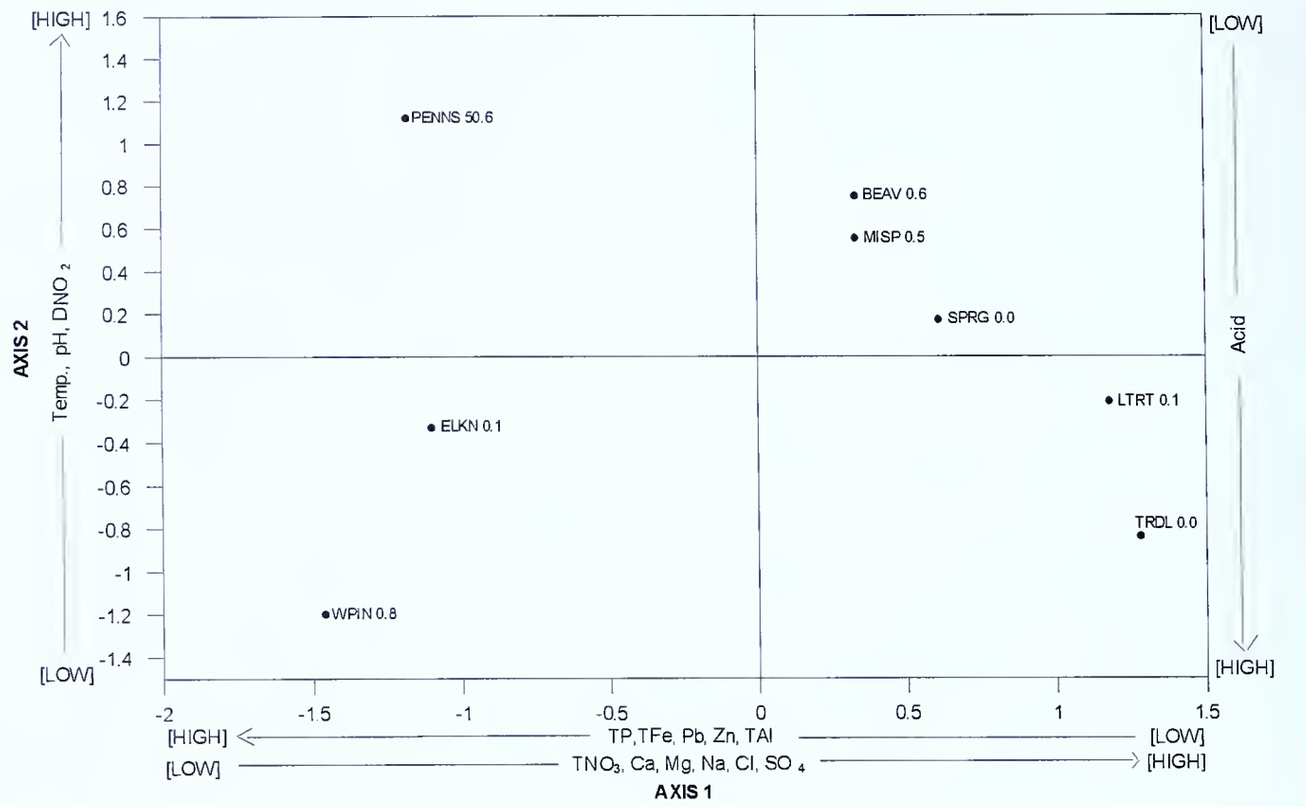


Figure 16. Map of Reference Category 67a Sample Sites



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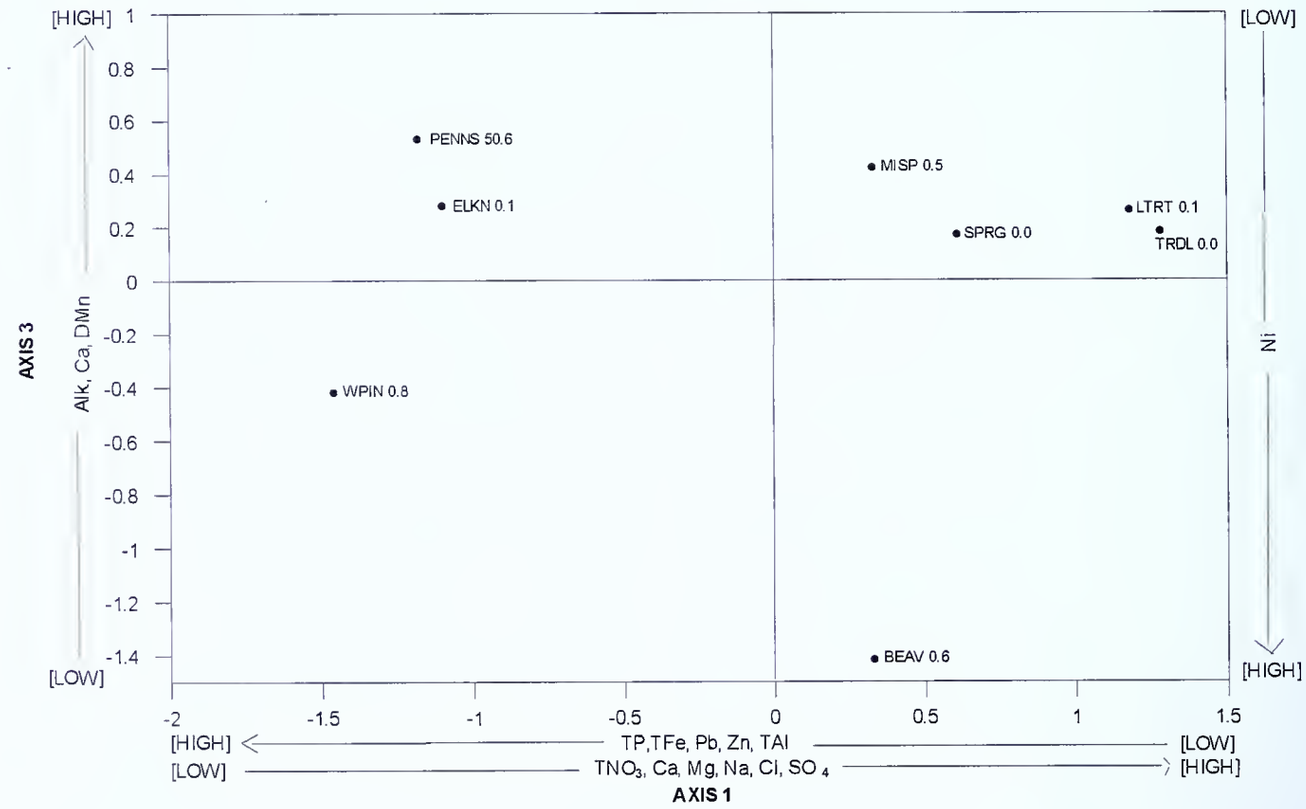
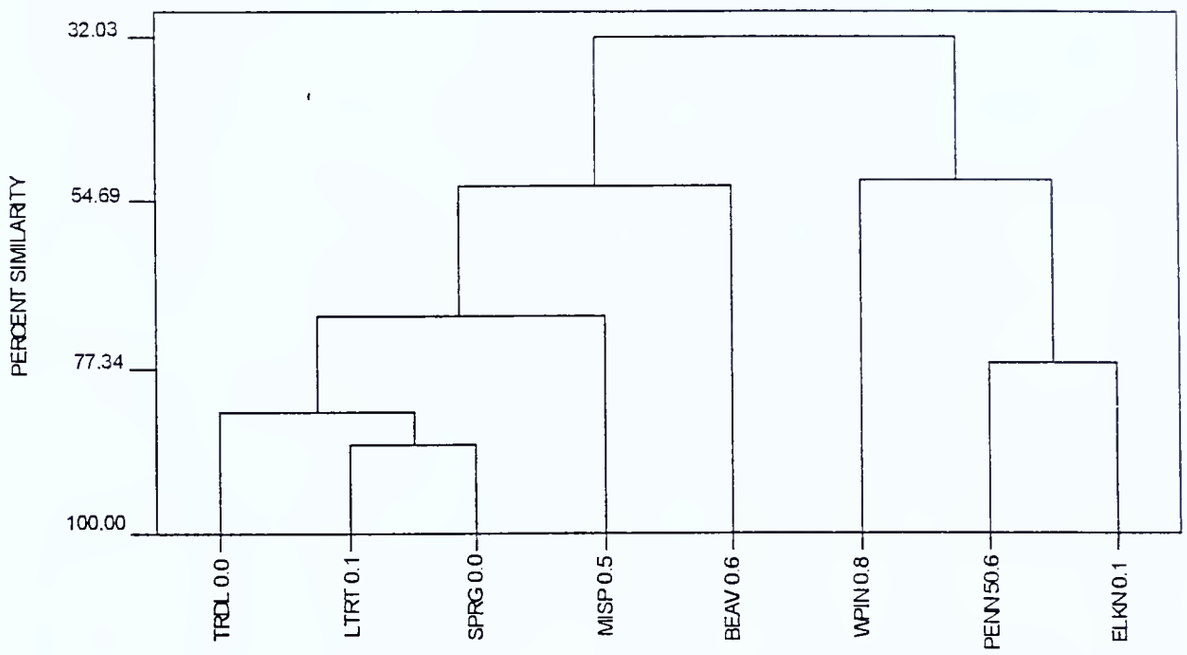


(b)

*Figure 17. **Ordinations of Reference Category 67a Sample Sites Based on Principal Components Analysis of Water Quality** ((a) PCA Axis 1 Versus PCA Axis 2, and (b) PCA Axis 1 Versus PCA Axis 3)*



Water Quality Variables Identified by PCA and Used to Generate Dendrogram

General Variables	Nutrients	Organic Matter	Ions	Metals
Temp	DNO_2		Ca	TFe
pH	TNO_3		Mg	Pb
Alk	TP		Na	DMn
Acid			Cl	Ni
			SO_4	Zn
				TAl

Figure 18. Cluster Analysis of Water Quality Parameters That Account for Most of the Variability in Reference Category 67a Water Quality Data

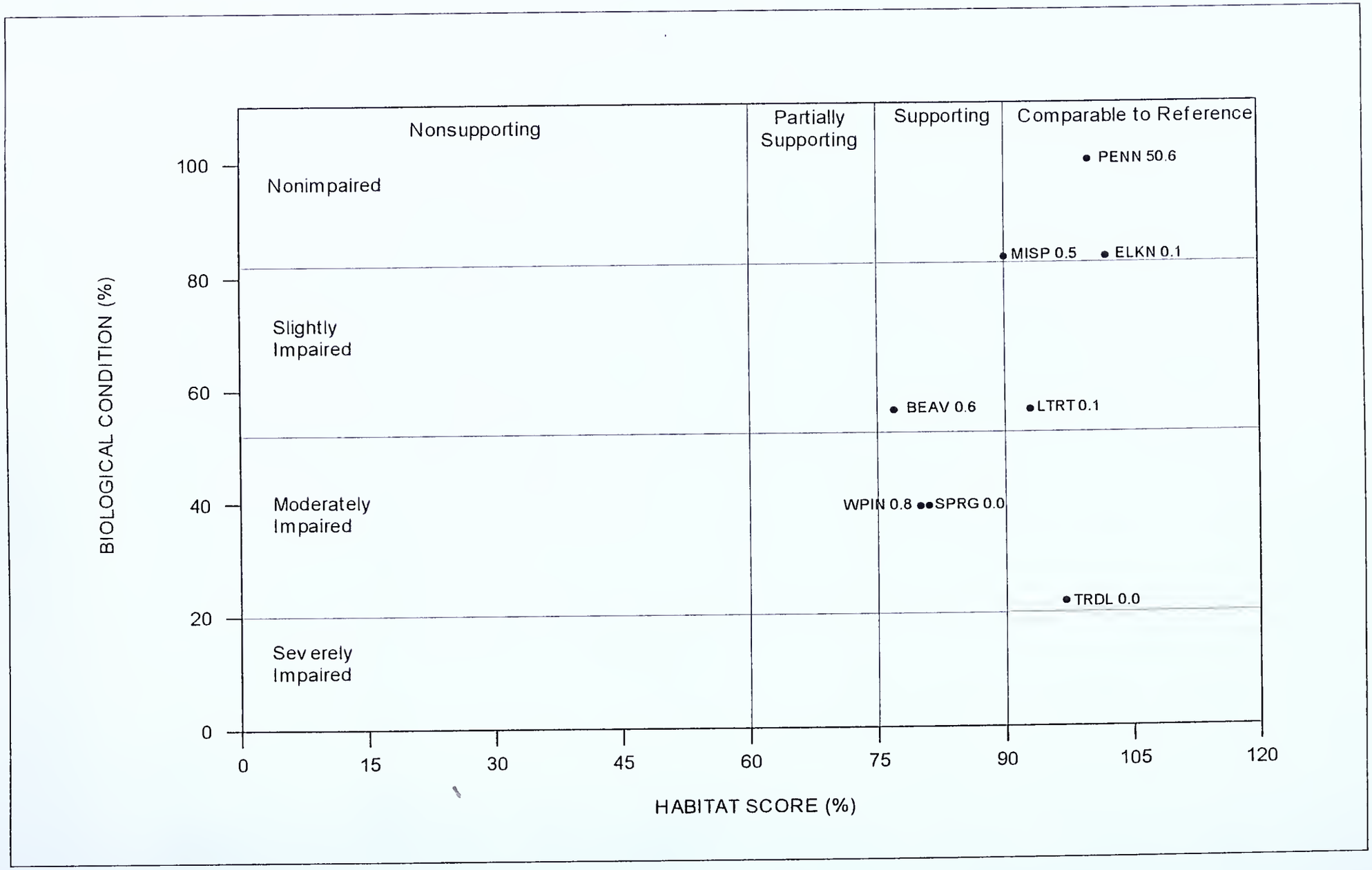


Figure 19. Summary of Reference Category 67a RBP III Biological and Habitat Data

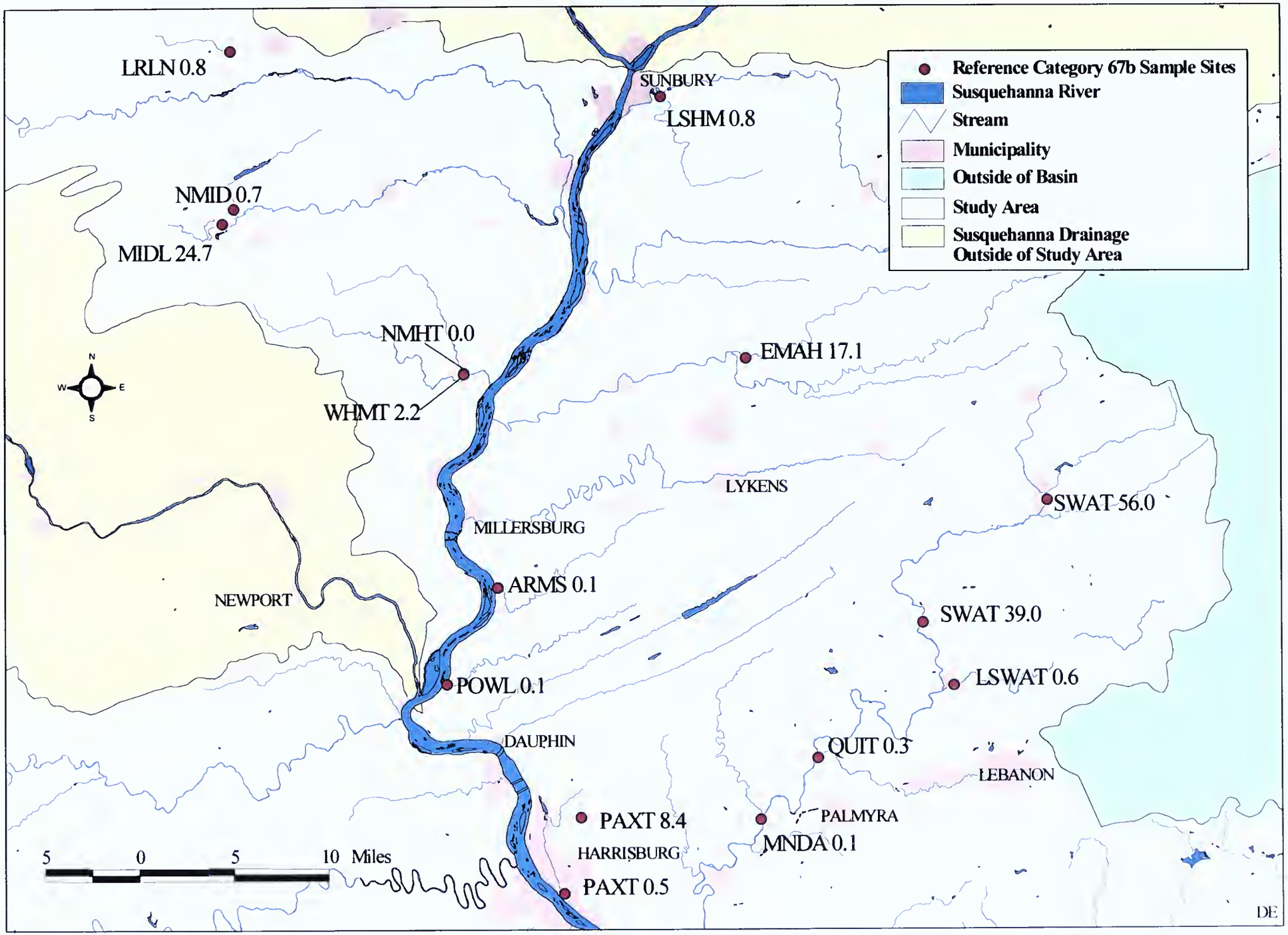
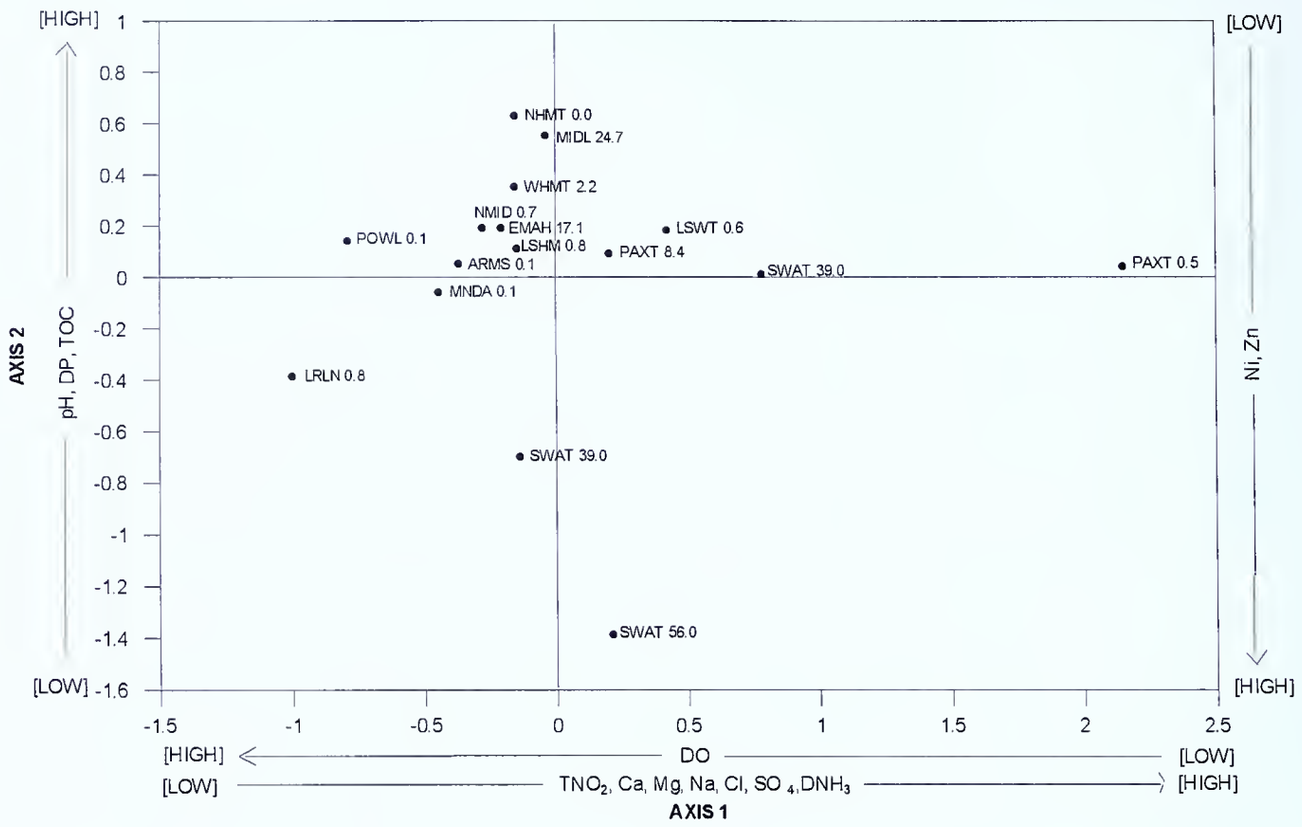
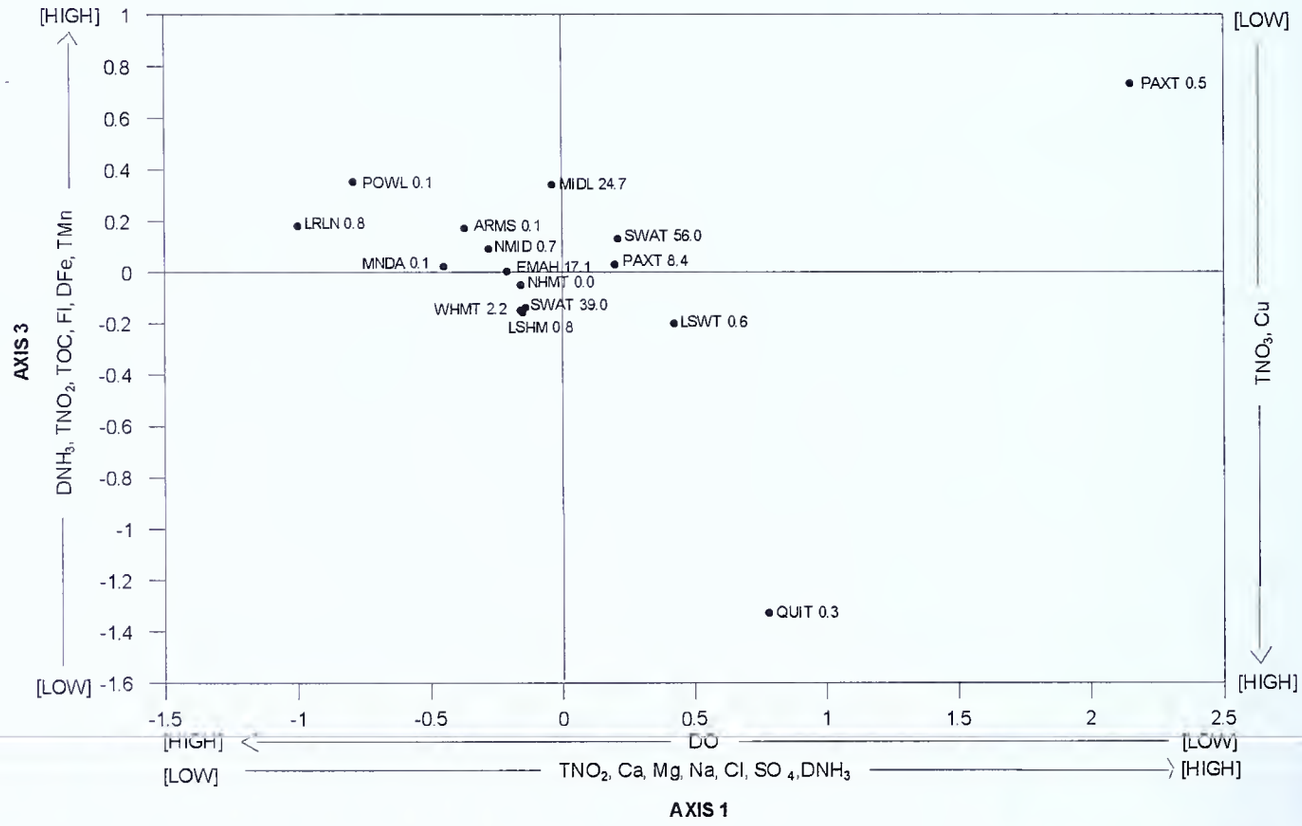


Figure 20. Map of Reference Category 67b Sample Sites

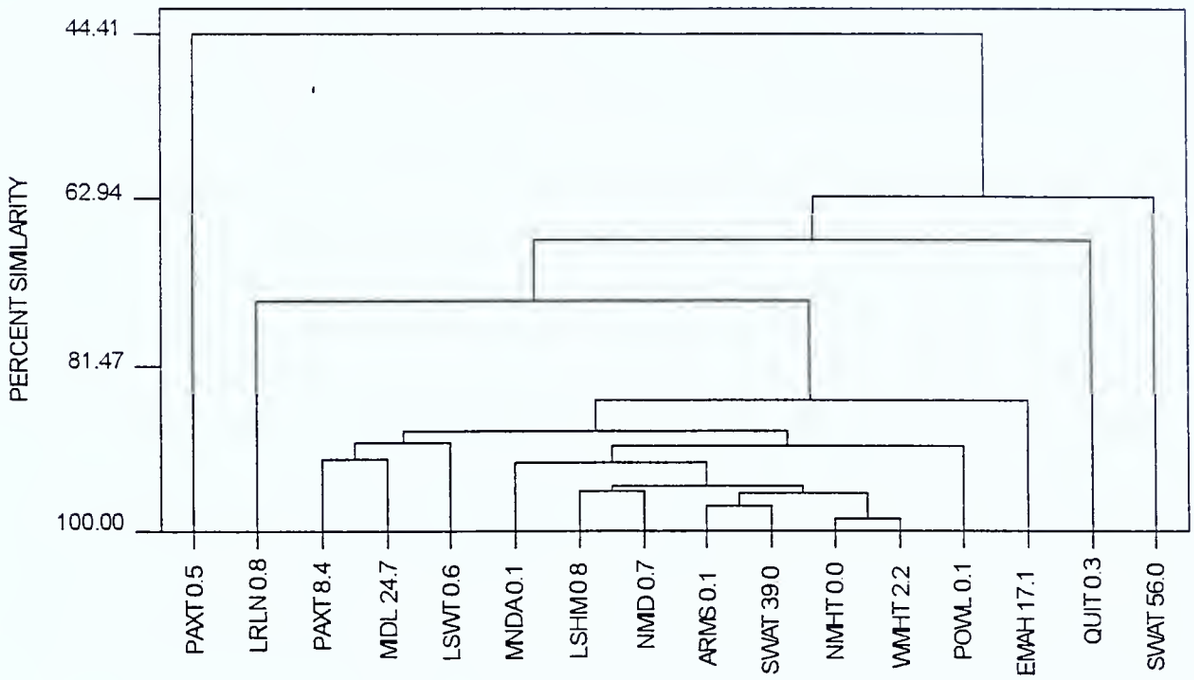


(a)



(b)

*Figure 21. **Ordinations of Reference Category 67b Sample Sites Based on Principal Components Analysis of Water Quality** ((a) PCA Axis 1 Versus PCA Axis 2, and (b) PCA Axis 1 Versus PCA Axis 3)*



Water Quality Variables Identified by PCA and Used to Generate Dendrogram

General Variables	Nutrients	Organic Matter	Ions	Metals
pH	DP	TOC	Ca	Cu
DO	TNO_2		Mg	DFe
	TNO_3		Na	TMn
	DNH_3		Cl	Ni
			SO_4	Zn
			Fl	

Figure 22. Cluster Analysis of Water Quality Parameters That Account for Most of the Variability in Reference Category 67b Water Quality Data

Table 16. Summary of Reference Category 67b RBP III Habitat Data

	WMHT 2.2	ARMS 0.1	EMAH 17.1	LRLN 0.8	LSHM 0.8	LSWT 0.6	MIDL 24.7	MNDA 0.1
Primary Parameters								
Bottom Substrate	18	18	18	19	16	14	15	10
Embeddedness	18	13	16	18	16	12	13	12
Velocity/Depth Diversity	16	18	19	18	14	17	18	15
Secondary Parameters								
Pool/Riffle Ratio	13	13	14	13	14	13	13	12
Pool Quality	12	11	14	14	11	11	14	11
Riffle/Run Quality	11	13	13	14	14	10	9	12
Channel Alteration	12	10	10	10	13	9	12	10
Tertiary Parameters								
Streambank Erosion	2	7	7	7	7	7	9	6
Streambank Stability	5	9	6	9	9	8	9	8
Streamside Vegetative Cover	7	7	9	8	9	6	9	7
Riparian Buffer Zone	7	4	8	9	8	4	9	4
Total Habitat Score								
Total Habitat Score	121	123	134	139	131	111	130	107
Habitat % of Reference	100	102	111	115	108	92	107	88

	NMHT 0.0	NMID 0.7	PAXT 0.5	PAXT 8.4	POWL 0.1	QUIT 0.3	SWAT 39.0	SWAT 56.0
Primary Parameters								
Bottom Substrate	15	13	0	11	18	12	16	15
Embeddedness	15	13	5	10	13	13	16	13
Velocity/Depth Diversity	14	18	1	13	18	17	19	6
Secondary Parameters								
Pool/Riffle Ratio	12	12	1	10	14	7	13	7
Pool Quality	11	13	1	6	13	14	14	6
Riffle/Run Quality	11	13	1	10	10	10	12	10
Channel Alteration	7	10	1	6	13	9	11	7
Tertiary Parameters								
Streambank Erosion	3	6	9	7	8	5	8	6
Streambank Stability	6	9	8	8	9	7	9	8
Streamside Vegetative Cover	8	9	6	8	6	7	8	6
Riparian Buffer Zone	5	9	2	4	4	5	8	7
Total Habitat Score								
Total Habitat Score	107	125	35	93	126	106	134	91
Habitat % of Reference	88	103	29	77	104	88	111	75

Table 17. Summary of Reference Category 67b RBP III Biological Data

	WMHT 2.2	ARMS 0.1	EMAH 17.1	LRLN 0.8	LSHM 0.8	LSWT 0.6	MIDL 24.7	MNDA 0.1
Raw Data Summary								
Number of Individuals	116	101	332	139	144	100	129	100
Percent Shredders	0.9	1.0	0.0	5.8	0.7	0.0	6.2	0.0
Percent Collector-Gatherers	6.9	9.9	19.3	2.9	13.2	51.0	9.3	26.0
Percent Filterer-Collectors	36.2	60.4	66.0	68.3	45.8	12.0	74.4	9.0
Percent Scrapers	34.5	17.8	8.7	1.4	18.8	37.0	7.8	59.0
Percent Predators	21.6	10.9	6.0	21.6	21.5	0.0	2.3	6.0
Number of EPT Taxa	9	7	6	11	9	7	3	6
Number of EPT Individuals	50	82	262	130	82	21	83	41
Metric Scores								
Taxonomic Richness	24	14	11	15	16	13	10	12
Diversity Index	3.72	2.60	2.43	2.51	3.20	2.66	2.56	3.07
Hilsenhoff Biotic Index	3.79	3.92	3.71	0.96	3.49	5.73	5.14	3.38
EPT Index	9	7	6	11	9	7	3	6
Taxonomic Similarity (%)	100.0	18.4	15.2	14.9	56.9	24.1	15.5	22.2
Trophic Similarity (%)	100.0	72.7	57.9	62.9	84.1	53.4	54.1	56.4
Percent of Reference								
Taxonomic Richness	100.0	58.3	45.8	62.5	66.7	54.2	41.7	50.0
Diversity Index	100.0	69.9	65.3	67.5	86.0	71.5	68.8	82.5
Hilsenhoff Biotic Index	100.0	96.7	102.3	393.5	108.8	66.2	73.8	112.2
EPT Index	100.0	77.8	66.7	122.2	100.0	77.8	33.3	66.7
Taxonomic Similarity (%)	100.0	18.4	15.2	14.9	56.9	24.1	15.5	22.2
Trophic Similarity (%)	100.0	72.7	57.9	62.9	84.1	53.4	54.1	56.4
Biological Condition Scores								
Taxonomic Richness	6	2	2	4	4	2	2	2
Diversity Index	6	4	4	4	6	4	4	6
Hilsenhoff Biotic Index	6	6	6	6	6	2	4	6
EPT Index	6	2	0	6	6	2	0	0
Taxonomic Similarity (%)	6	0	0	0	6	2	0	2
Trophic Similarity (%)	6	4	4	4	6	4	4	4
Total Biological Score								
Total Biological Score	36	18	16	24	34	16	14	20
Biological % of Reference	100	50	44	67	94	44	39	56

Table 17. Summary of Reference Category 67b RBP III Biological Data—Continued

	NMHT 0.0	NMID 0.7	PAXT 8.4	POWL 0.1	QUIT 0.3	SWAT 39.0	SWAT 56.0
Raw Data Summary							
Number of Individuals	214	117	102	144	100	112	40
Percent Shredders	6.5	1.7	15.7	0.0	60.0	0.0	2.5
Percent Collector-Gatherers	40.2	44.4	24.5	41.0	2.0	8.9	30.0
Percent Filterer-Collectors	29.4	24.8	6.9	47.9	16.0	77.7	2.5
Percent Scrapers	20.6	20.5	52.9	6.9	19.0	9.8	12.5
Percent Predators	3.3	8.5	0.0	4.2	3.0	3.6	52.5
Number of EPT Taxa	11	7	5	8	2	9	3
Number of EPT Individuals	105	37	19	127	13	102	3
Metric Scores							
Taxonomic Richness	20	18	11	15	13	15	8
Diversity Index	3.56	2.96	2.64	2.42	2.43	2.68	1.89
Hilsenhoff Biotic Index	5.10	5.32	5.37	4.77	5.53	4.36	5.90
EPT Index	11	7	5	8	2	9	3
Taxonomic Similarity (%)	33.3	34.3	22.2	10.8	14.8	32.5	21.8
Trophic Similarity (%)	61.0	61.6	49.1	54.2	40.9	56.5	44.3
Percent of Reference							
Taxonomic Richness	83.3	75.0	45.8	62.5	54.2	62.5	33.3
Diversity Index	95.7	79.6	71.0	65.1	65.3	72.0	50.8
Hilsenhoff Biotic Index	74.4	71.2	70.6	79.5	68.6	87.1	64.3
EPT Index	122.2	77.8	55.6	88.9	22.2	100.0	33.3
Taxonomic Similarity (%)	33.3	34.3	22.2	10.8	14.8	32.5	21.8
Trophic Similarity (%)	61.0	61.6	49.1	54.2	40.9	56.5	44.3
Biological Condition Scores							
Taxonomic Richness	6	4	2	4	2	4	0
Diversity Index	6	6	4	4	4	4	4
Hilsenhoff Biotic Index	4	4	4	4	2	6	2
EPT Index	6	2	0	4	0	6	0
Taxonomic Similarity (%)	4	4	2	0	0	2	2
Trophic Similarity (%)	4	4	2	4	2	4	2
Total Biological Score							
Total Biological Score	30	24	14	20	10	26	10
Biological % of Reference	83	67	39	56	28	72	28

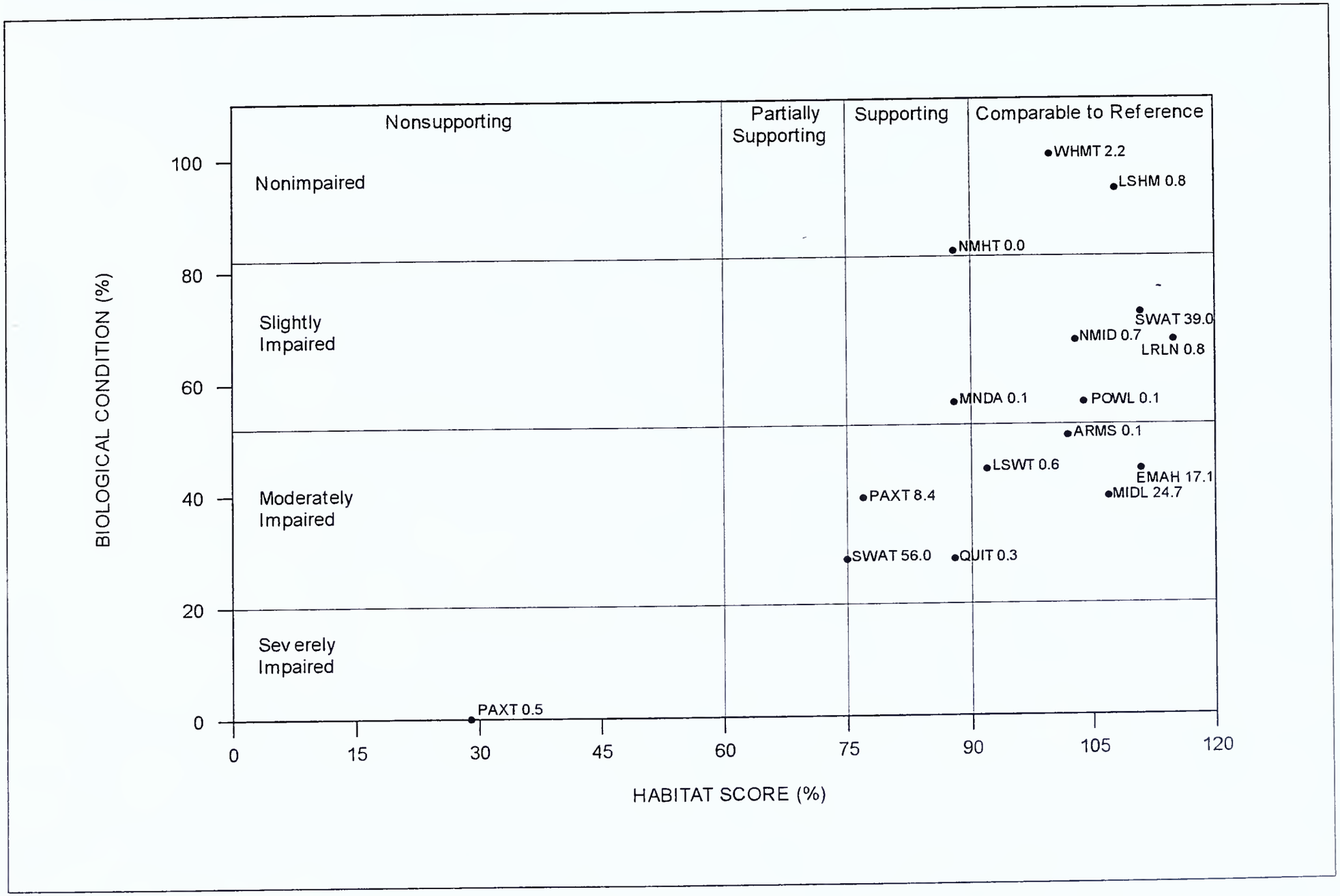


Figure 23. Summary of Reference Category 67b RBP III Biological and Habitat Data

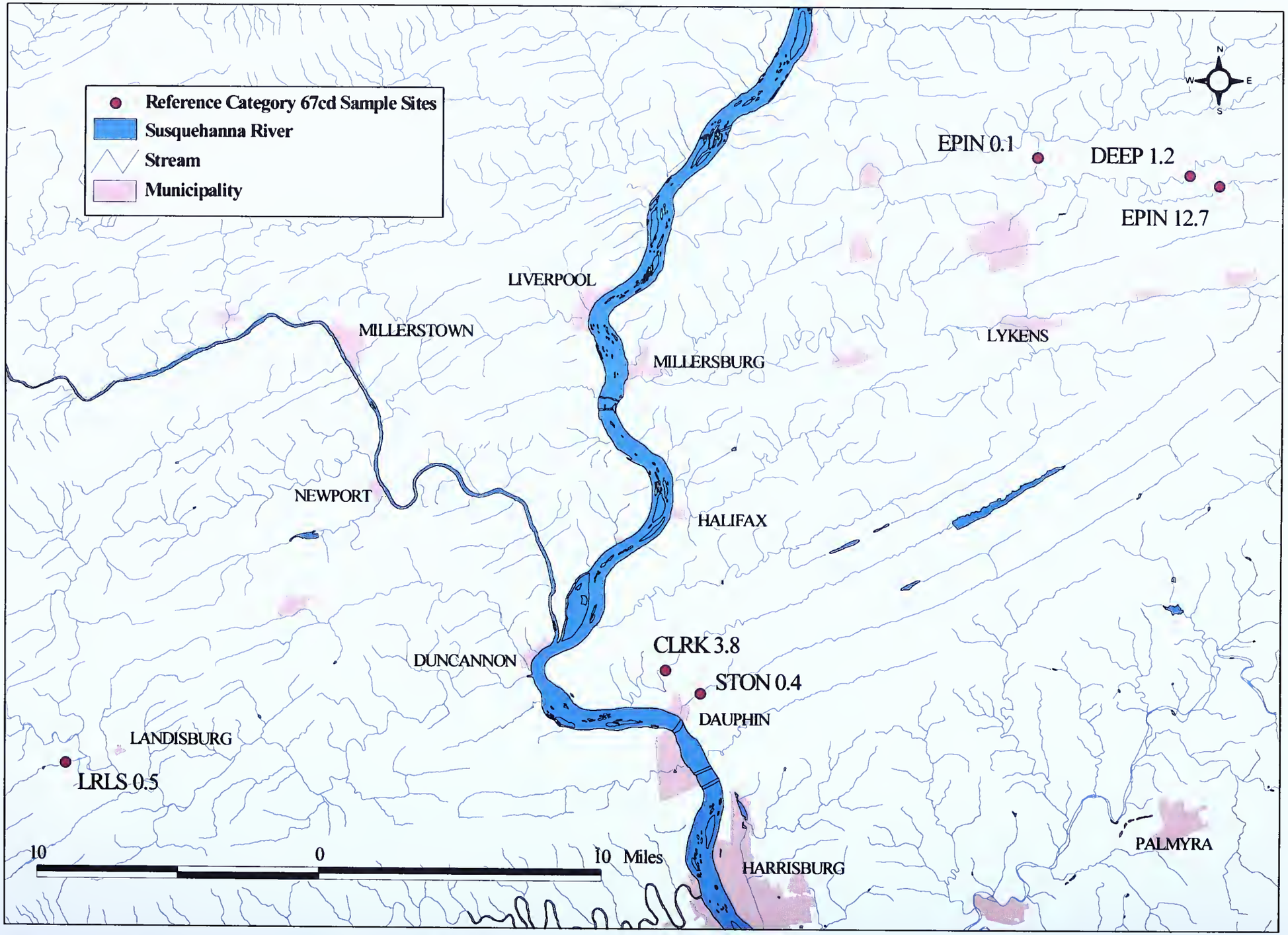
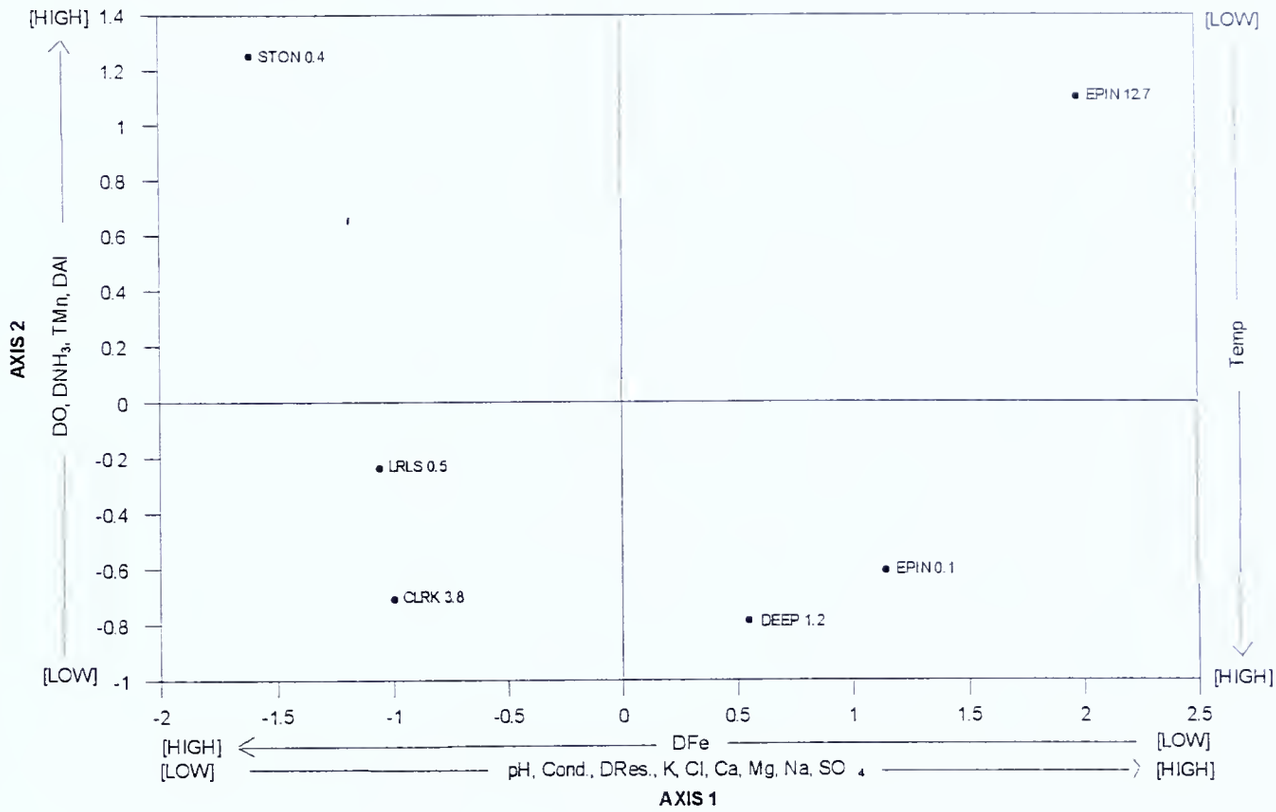
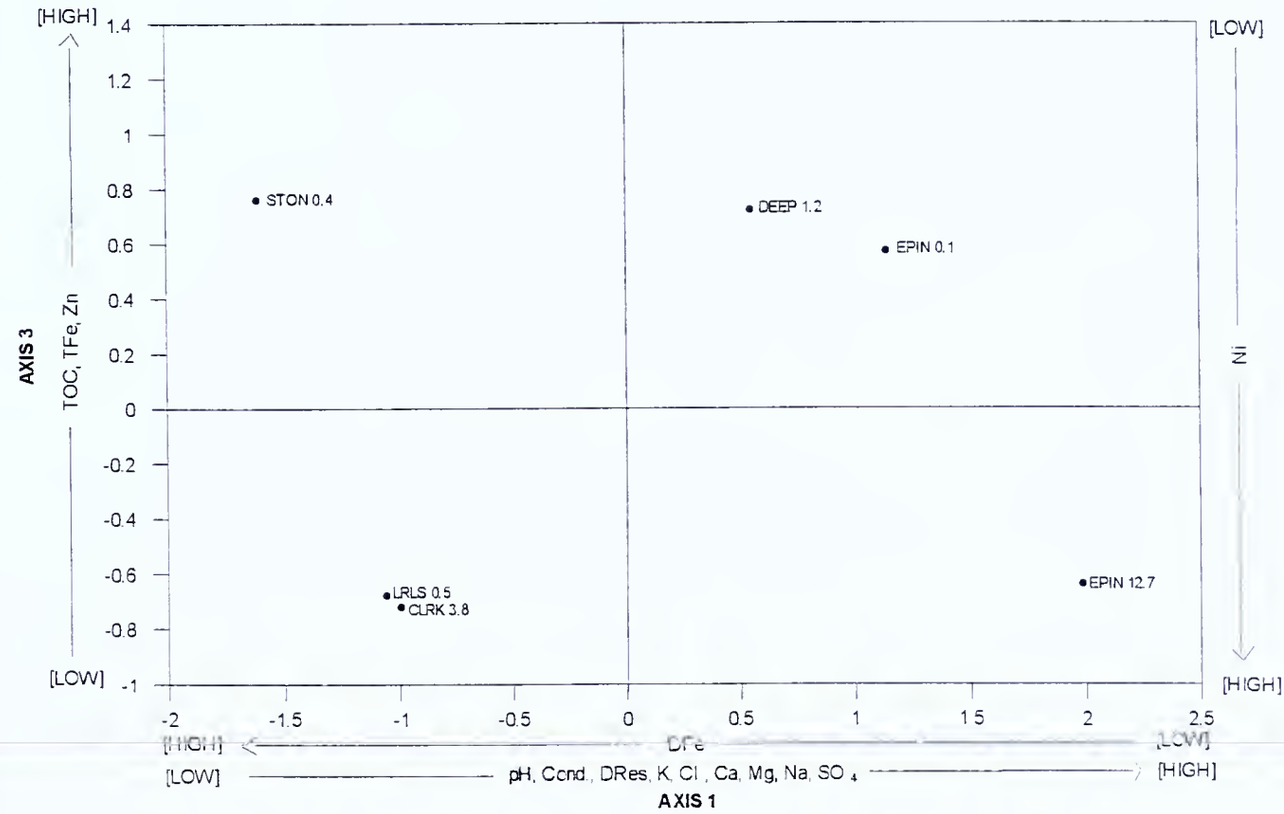


Figure 24. Map of Reference Category 67cd Sample Sites

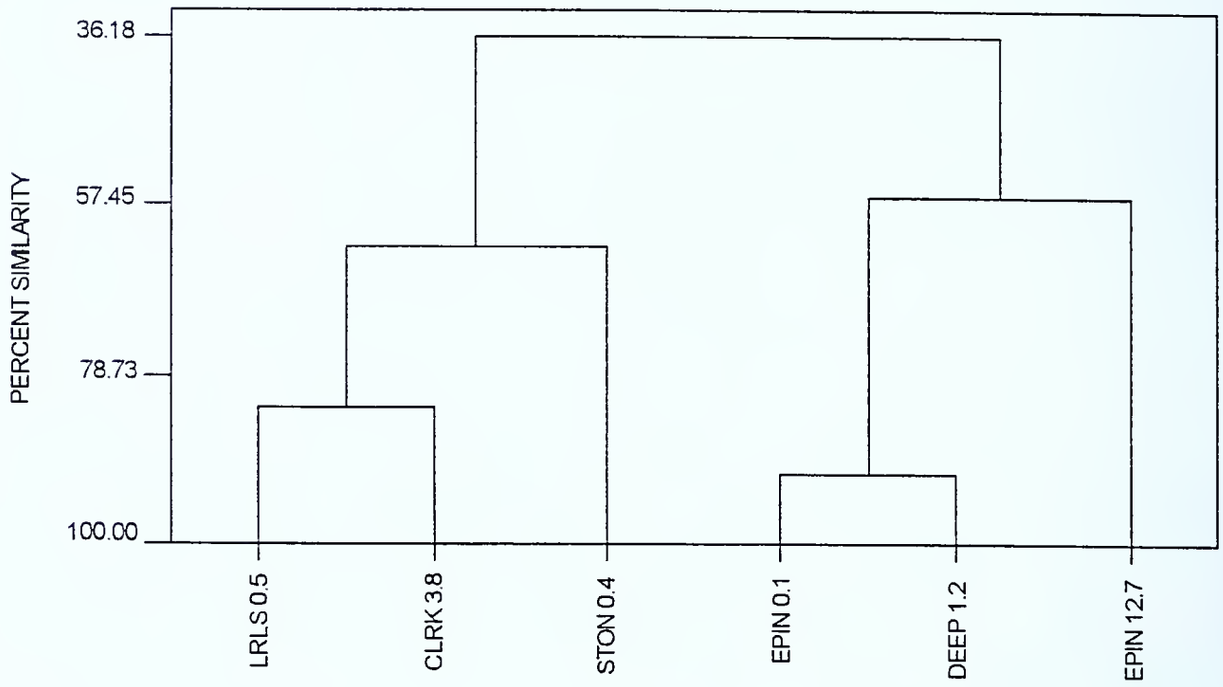


(a)



(b)

Figure 25. Ordinations of Reference Category 67cd Sample Sites Based on Principal Components Analysis of Water Quality ((a) PCA Axis 1 Versus PCA Axis 2, and (b) PCA Axis 1 Versus PCA Axis 3)



Water Quality Variables Identified by PCA and Used to Generate Dendrogram

General Variables	Nutrients	Organic Matter	Ions	Metals
Temp	DNH_3	TOC	Ca	TFe
DO			Mg	DFe
pH			Na	TMn
Cond			Cl	Ni
DRes			SO_4	Zn
			K	DAl

Figure 26. Cluster Analysis of Water Quality Parameters That Account for Most of the Variability in Reference Category 67cd Water Quality Data

Table 18. Summary of Reference Category 67cd RBP III Habitat Data

	STON 0.4	CLRK 3.8	DEEP 1.2	EPIN 0.1	EPIN 12.7	LRLS 0.5
Primary Parameters						
Bottom Substrate	19	18	18	19	13	17
Embeddedness	15	15	14	13	16	17
Velocity/Depth Diversity	18	13	17	17	19	17
Secondary Parameters						
Pool/Riffle Ratio	14	6	13	9	13	13
Pool Quality	14	6	12	12	14	12
Riffle/Run Quality	13	8	12	12	14	12
Channel Alteration	10	11	13	13	13	12
Tertiary Parameters						
Streambank Erosion	8	9	8	7	9	7
Streambank Stability	9	9	8	9	8	9
Streamside Vegetative Cover	8	7	9	8	8	9
Riparian Buffer Zone	4	4	4	4	6	4
Total Habitat Score						
Total Habitat Score	132	106	128	123	133	129
Habitat % of Reference	100	80	97	93	101	98

Table 19. Summary of Reference Category 67cd RBP III Biological Data

	STON 0.4	CLRK 3.8	DEEP 1.2	EPIN 0.1	EPIN 12.7	LRLS 0.5
Raw Data Summary						
Number of Individuals	117	102	119	149	171	41
Percent Shredders	6.0	4.9	0.8	2.7	0.6	2.4
Percent Collector-Gatherers	27.4	24.5	4.2	31.5	69.6	24.4
Percent Filterer-Collectors	42.7	30.4	57.1	45.6	21.6	39.0
Percent Scrapers	6.0	14.7	26.9	9.4	2.9	4.9
Percent Predators	17.9	25.5	10.9	10.7	5.3	29.3
Number of EPT Taxa	10	16	9	7	12	6
Number of EPT Individuals	84	63	87	114	67	26
Metric Scores						
Taxonomic Richness	19	24	16	14	19	13
Diversity Index	3.62	4.21	3.12	2.71	2.44	3.21
Hilsenhoff Biotic Index	3.81	3.56	3.30	4.57	5.91	4.61
EPT Index	10	16	9	7	12	6
Taxonomic Similarity (%)	100.0	38.4	40.7	36.8	34.7	30.4
Trophic Similarity (%)	100.0	83.7	64.68	89.5	57.8	88.7
Percent of Reference						
Taxonomic Richness	100.0	126.3	84.2	73.7	100.0	68.4
Diversity Index	100.0	116.3	86.2	74.9	67.4	88.7
Hilsenhoff Biotic Index	100.0	107.1	115.4	83.4	64.5	82.7
EPT Index	100.0	160.0	90.0	70.0	120.0	60.0
Taxonomic Similarity (%)	100.0	38.4	40.7	36.8	34.7	30.4
Trophic Similarity (%)	100.0	83.7	64.7	89.5	57.8	88.7
Biological Condition Scores						
Taxonomic Richness	6	6	6	4	6	4
Diversity Index	6	6	6	4	4	6
Hilsenhoff Biotic Index	6	6	6	4	2	4
EPT Index	6	6	6	2	6	0
Taxonomic Similarity (%)	6	4	4	4	4	2
Trophic Similarity (%)	6	6	4	6	4	6
Total Biological Score						
Total Biological Score	36	34	32	24	26	22
Biological % of Reference	100	94	89	67	72	61

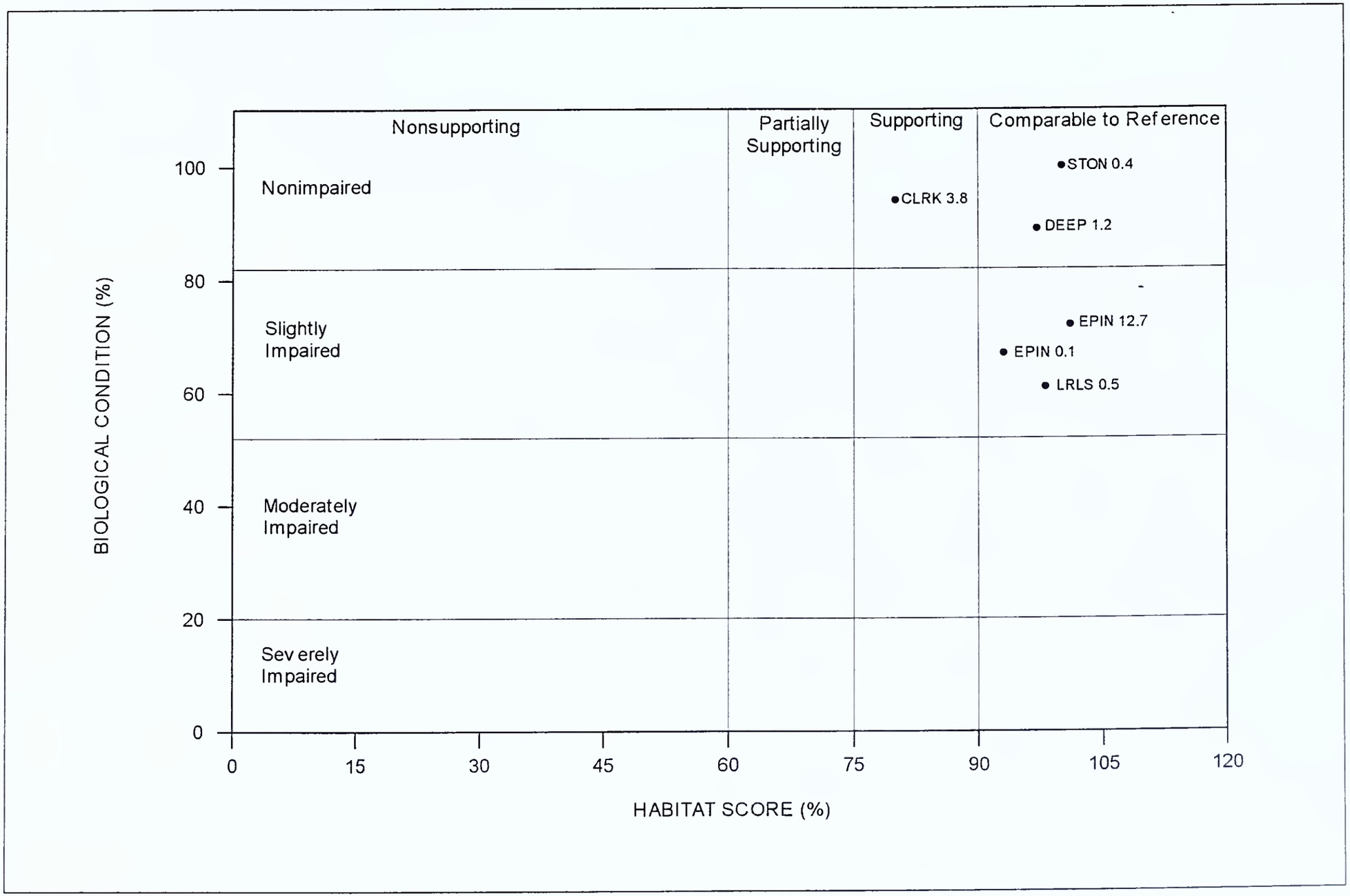


Figure 27. Summary of Reference Category 67cd RBP III Biological and Habitat Data

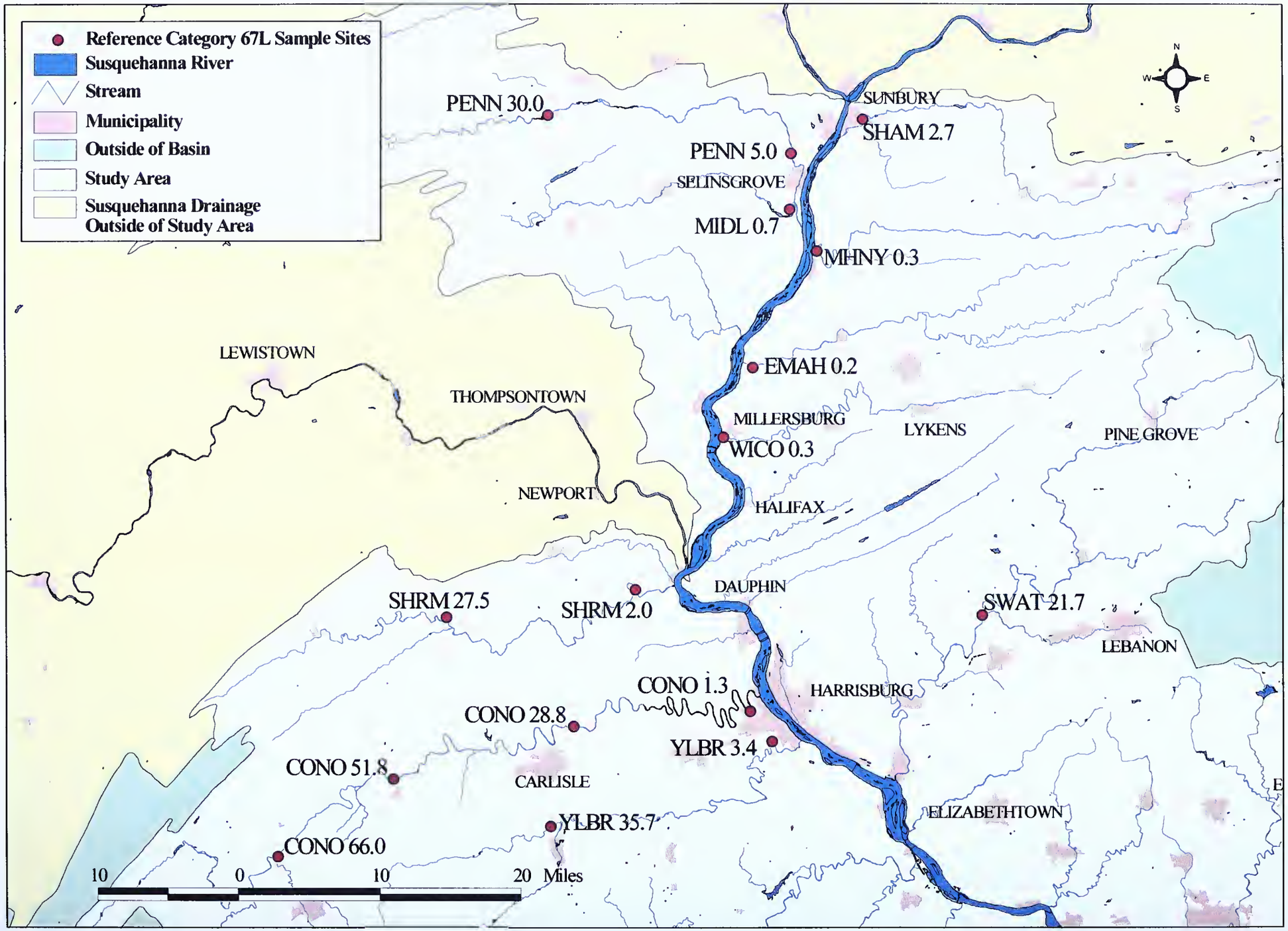
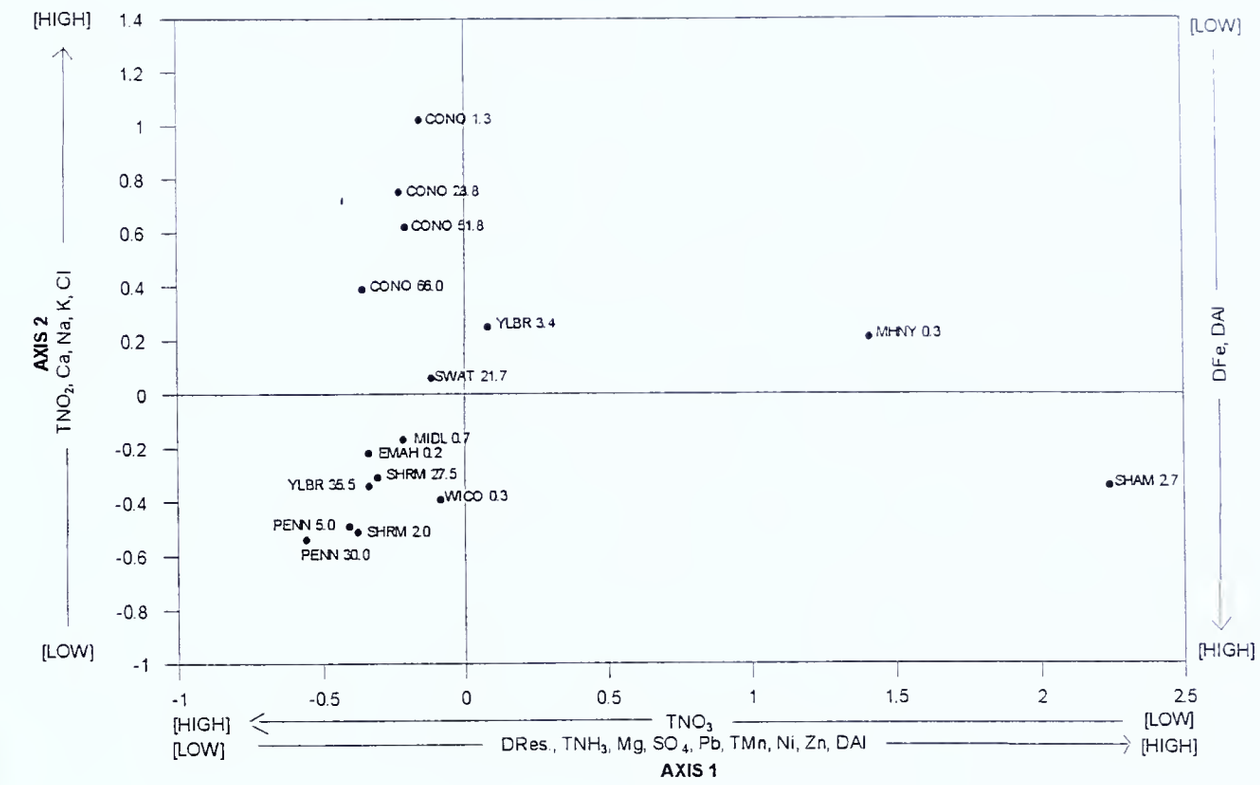
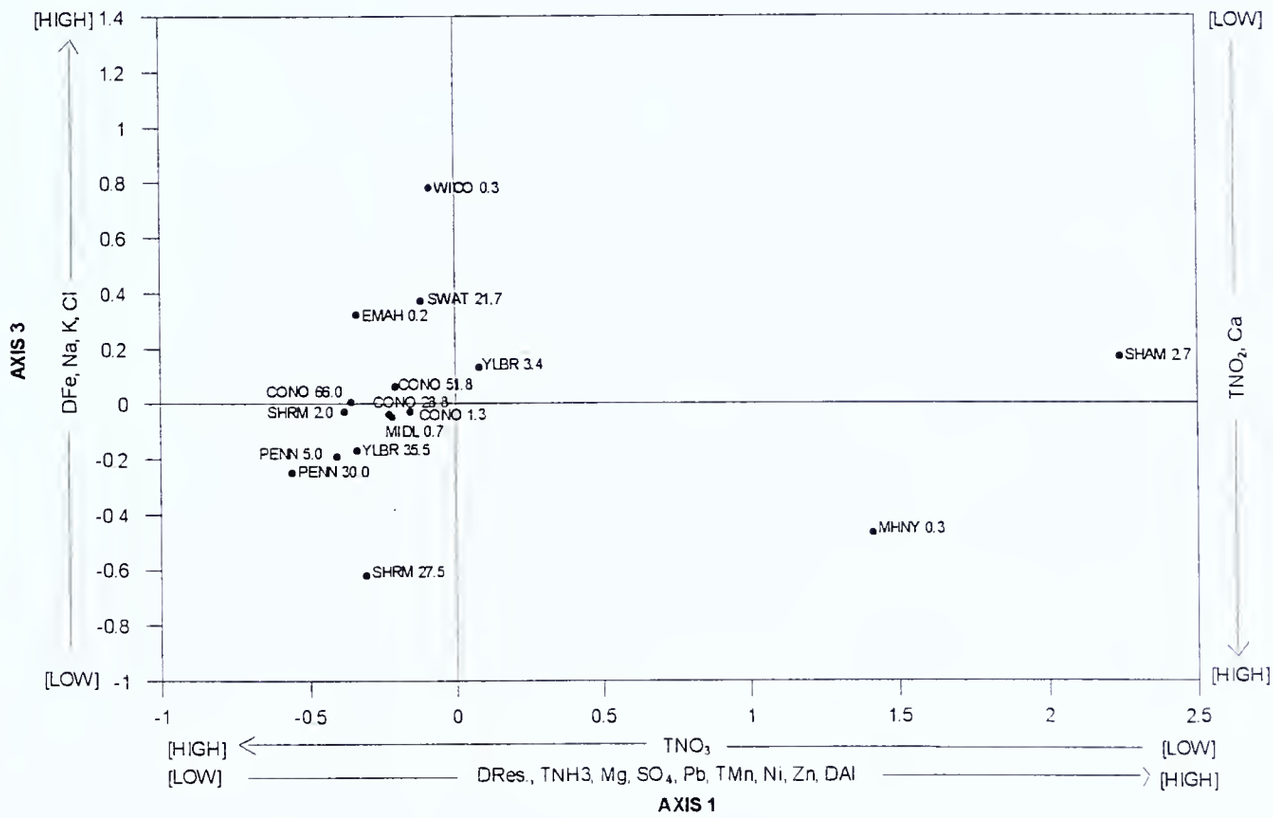


Figure 28. Map of Reference Category 67L Sample Sites

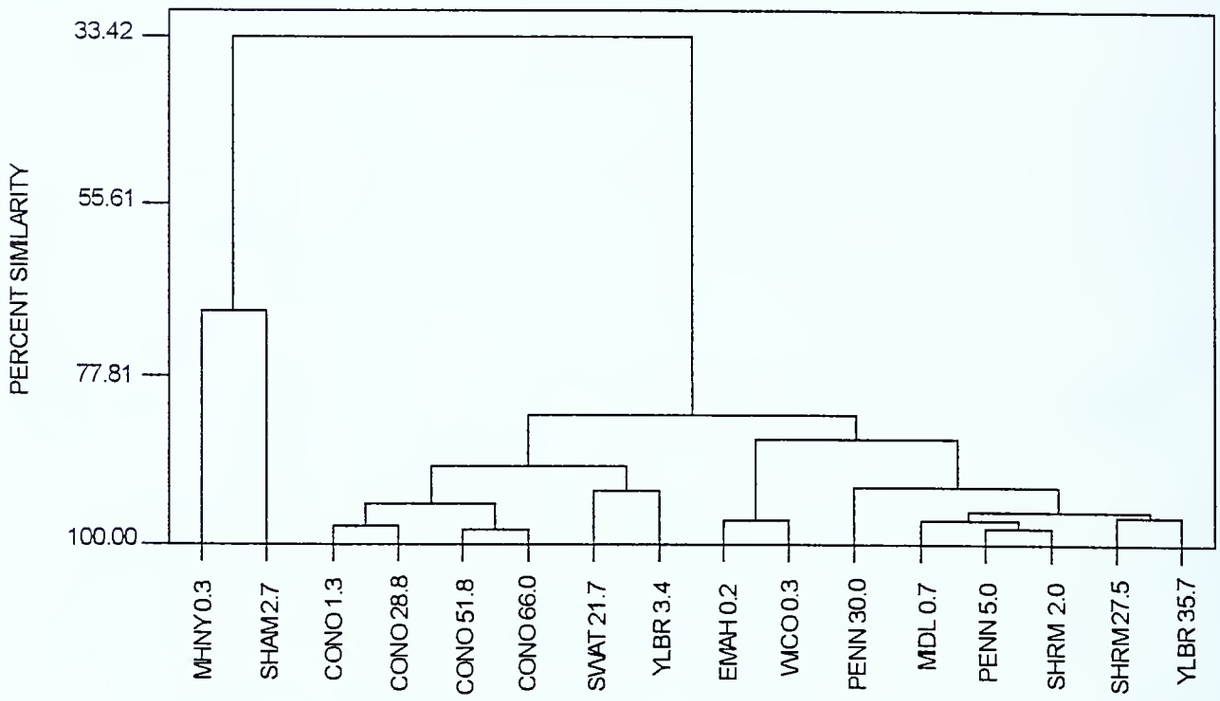


(a)



(b)

Figure 29. Ordinations of Reference Category 67L Sample Sites Based on Principal Components Analysis of Water Quality ((a) PCA Axis 1 Versus PCA Axis 2, and (b) PCA Axis 1 Versus PCA Axis 3)



Water Quality Variables Identified by PCA and Used to Generate Dendrogram

General Variables	Nutrients	Organic Matter	Ions	Metals
DRes	TNH_3		Ca	Pb
	TNO_2		Mg	DFe
	TNO_3		Na	TMn
			Cl	Ni
			SO_4	Zn
			K	DAl

Figure 30. Cluster Analysis of Water Quality Parameters That Account for Most of the Variability in Reference Category 67L Water Quality Data

Table 20. Summary of Reference Category 67L RBP III Habitat Data

	PENN 30.0	CONO 1.3	CONO 28.3	CONO 51.8	CONO 66.0	EMAH 0.2	MHNY 0.3	MIDL 0.7
Primary Parameters								
Bottom Substrate	18	6	8	15	12	16	18	10
Embeddedness	14	9	12	11	12	14	11	11
Velocity/Depth Diversity	19	8	9	17	18	18	18	16
Secondary Parameters								
Pool/Riffle Ratio	14	3	4	6	9	13	14	9
Pool Quality	14	9	9	12	12	14	13	12
Riffle/Run Quality	14	11	11	12	9	11	13	7
Channel Alteration	13	12	10	8	13	11	13	12
Tertiary Parameters								
Streambank Erosion	7	5	5	7	5	8	9	8
Streambank Stability	7	7	8	7	9	9	9	8
Streamside Vegetative Cover	8	7	6	6	7	9	8	9
Riparian Buffer Zone	7	2	3	4	4	5	4	8
Total Habitat Score								
Total Habitat Score	135	79	85	105	110	128	130	110
Habitat % of Reference	100	59	63	78	81	95	96	81

	PENN 5.0	SHAM 2.7	SHRM 2.0	SHRM 27.5	SWAT 21.7	WICO 0.3	YLBR 3.4	YLBR 35.7
Primary Parameters								
Bottom Substrate	18	4	14	16	14	13	10	8
Embeddedness	15	7	17	14	13	17	9	8
Velocity/Depth Diversity	18	16	18	14	12	18	18	17
Secondary Parameters								
Pool/Riffle Ratio	11	11	10	11	8	12	11	13
Pool Quality	12	14	11	13	12	13	10	11
Riffle/Run Quality	13	6	13	13	11	13	13	12
Channel Alteration	12	12	13	12	10	11	12	10
Tertiary Parameters								
Streambank Erosion	9	8	7	7	7	7	7	8
Streambank Stability	9	8	9	9	8	9	9	9
Streamside Vegetative Cover	8	9	6	4	8	8	8	9
Riparian Buffer Zone	4	5	4	6	4	4	5	5
Total Habitat Score								
Total Habitat Score	129	100	122	119	107	125	112	110
Habitat % of Reference	96	74	90	88	79	93	83	81

Table 21. Summary of Reference Category 67L RBP III Biological Data

	PENN 30.0	CONO 1.3	CONO 28.8	CONO 51.8	CONO 66.0	EMAH 0.2	MHNY 0.3	MIDL 0.7	PENN 5.0	SHRM 2.0	SHRM 27.5	WICO 0.3	YLBR 3.4	YLBR 35.7
Raw Data Summary														
Number of Individuals	172	143	143	170	108	102	99	205	135	143	143	127	120	165
Percent Shredders	0.0	1.4	2.1	1.2	0.9	2.0	0.0	0.5	0.7	0.0	1.4	0.8	33.3	7.9
Percent Collector-Gatherers	34.9	29.4	9.1	27.6	17.6	32.4	16.2	34.6	37.0	9.1	9.1	28.3	14.2	20.6
Percent Filterer-Collectors	37.2	22.4	18.2	33.5	47.2	12.7	62.6	38.5	18.5	67.8	67.8	64.6	15.0	10.9
Percent Scrapers	17.4	39.2	68.5	31.8	34.3	51.0	6.1	24.9	34.1	18.2	16.8	4.7	34.2	58.2
Percent Predators	10.5	7.7	2.1	5.9	0.0	2.0	15.2	1.5	9.6	4.9	4.9	1.6	3.3	2.4
Number of EPT Taxa	15	10	8	14	8	11	2	10	14	12	11	9	8	13
Number of EPT Individuals	126	93	56	78	73	81	62	126	80	116	88	107	40	57
Metric Scores														
Taxonomic Richness	23	17	17	26	14	19	8	17	24	20	20	14	17	23
Diversity Index	3.71	3.30	3.08	3.60	3.32	3.24	1.91	3.35	4.09	3.32	3.30	2.80	3.27	3.60
Hilsenhoff Biotic Index	3.27	4.55	4.37	5.01	4.17	3.79	4.75	4.55	4.57	3.59	4.04	3.99	4.76	4.53
EPT Index	15	10	8	14	8	11	2	10	14	12	11	9	8	13
Taxonomic Similarity (%)	100.0	34.3	32.2	50.0	37.2	26.6	50.4	58.4	39.1	58.4	52.1	54.9	28.8	34.4
Trophic Similarity (%)	100.0	76.9	46.8	84.5	72.2	64.5	69.9	90.7	80.5	68.6	68.0	71.9	49.9	51.6
Percent of Reference														
Taxonomic Richness	100.0	73.9	73.9	113.0	60.9	82.6	34.8	73.9	104.3	87.0	87.0	60.9	73.9	100.0
Diversity Index	100.0	88.9	83.0	97.0	89.5	87.3	51.5	90.3	110.2	89.5	88.9	75.5	88.1	97.0
Hilsenhoff Biotic Index	100.0	71.8	74.8	65.3	78.4	86.1	68.8	71.8	71.5	90.9	80.8	81.8	68.7	72.1
EPT Index	100.0	66.7	53.3	93.3	53.3	73.3	13.3	66.7	93.3	80.0	73.3	60.0	53.3	86.7
Taxonomic Similarity (%)	100.0	34.3	32.2	50.0	37.2	26.6	50.4	58.4	39.1	58.4	52.1	54.9	28.8	34.4
Trophic Similarity (%)	100.0	76.9	46.8	84.5	72.2	64.5	69.9	90.7	80.5	68.6	68.0	71.9	49.9	51.6
Biological Condition Scores														
Taxonomic Richness	6	4	4	6	4	6	0	4	6	6	6	4	4	6
Diversity Index	6	6	6	6	6	6	4	6	6	6	6	6	6	6
Hilsenhoff Biotic Index	6	4	4	2	4	6	2	4	4	6	4	4	2	4
EPT Index	6	0	0	6	0	2	0	0	6	4	2	0	0	4
Taxonomic Similarity (%)	6	4	2	6	4	2	6	6	4	6	6	6	2	4
Trophic Similarity (%)	6	6	2	6	4	4	4	6	6	4	4	4	2	4
Total Biological Score														
Total Biological Score	36	24	18	32	22	26	16	26	32	32	28	24	16	28
Biological % of Reference	100	67	50	89	61	72	44	72	89	89	78	67	44	78

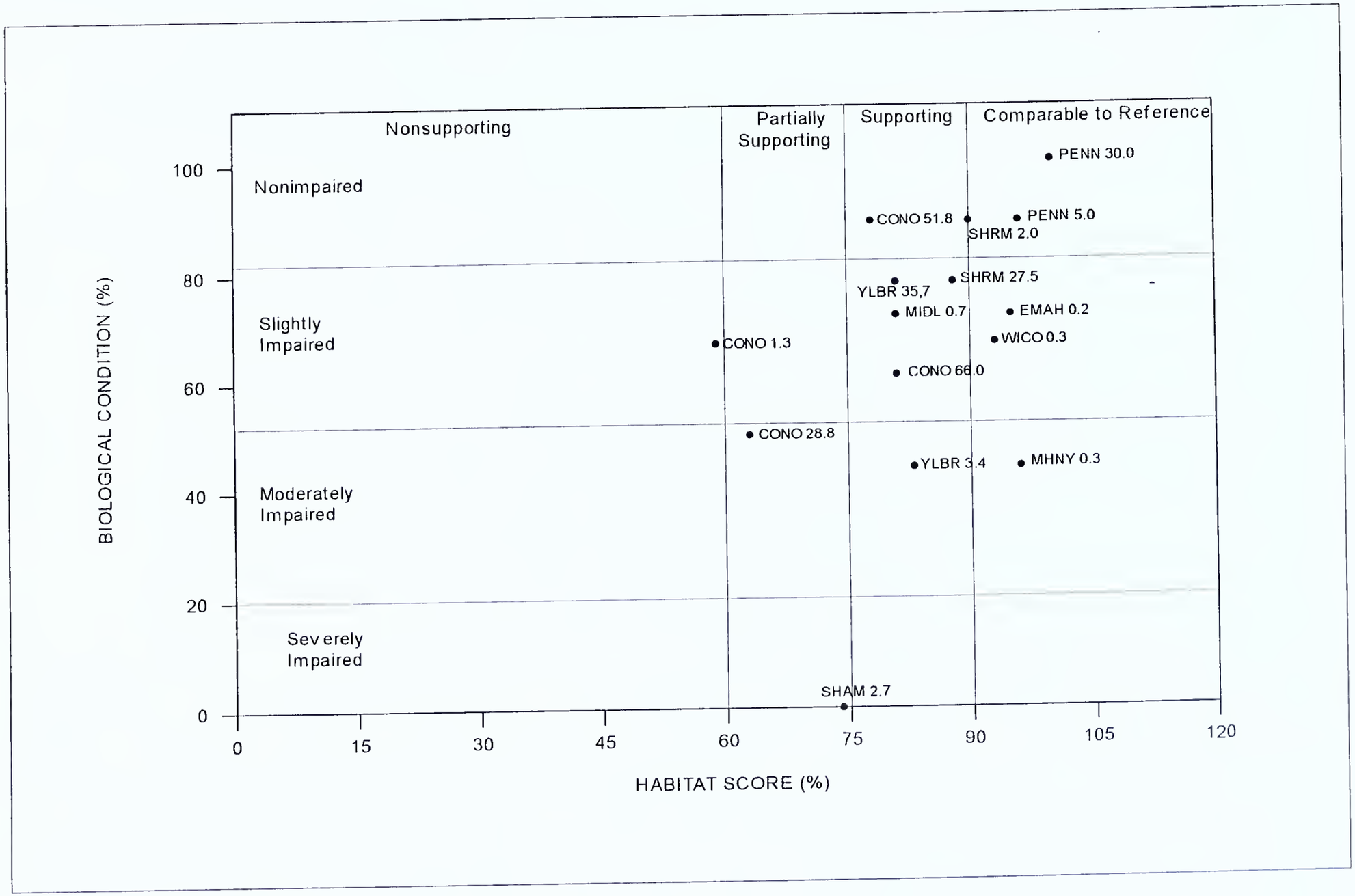


Figure 31. Summary of Reference Category 67L RBP III Biological and Habitat Data

Susquehanna River Sites

Six sample sites on the Susquehanna River (Figure 32) were assessed for habitat, biological health, and water quality. Additionally, a water sample was taken at the Conowingo Dam (SUSQ 10.0) to survey water quality near the mouth. A subset of 18 parameters that account for most the variation in the data were identified by PCA. The results of principal components and cluster analyses are presented in Figures 33 and 34, respectively.

Biological conditions at three of the six surveyed sites are nonimpaired, and the remaining three are slightly impaired. Habitat conditions are excellent at all sites. RBP III physical habitat and biological data are summarized in Tables 22 and 23 and Figure 35.

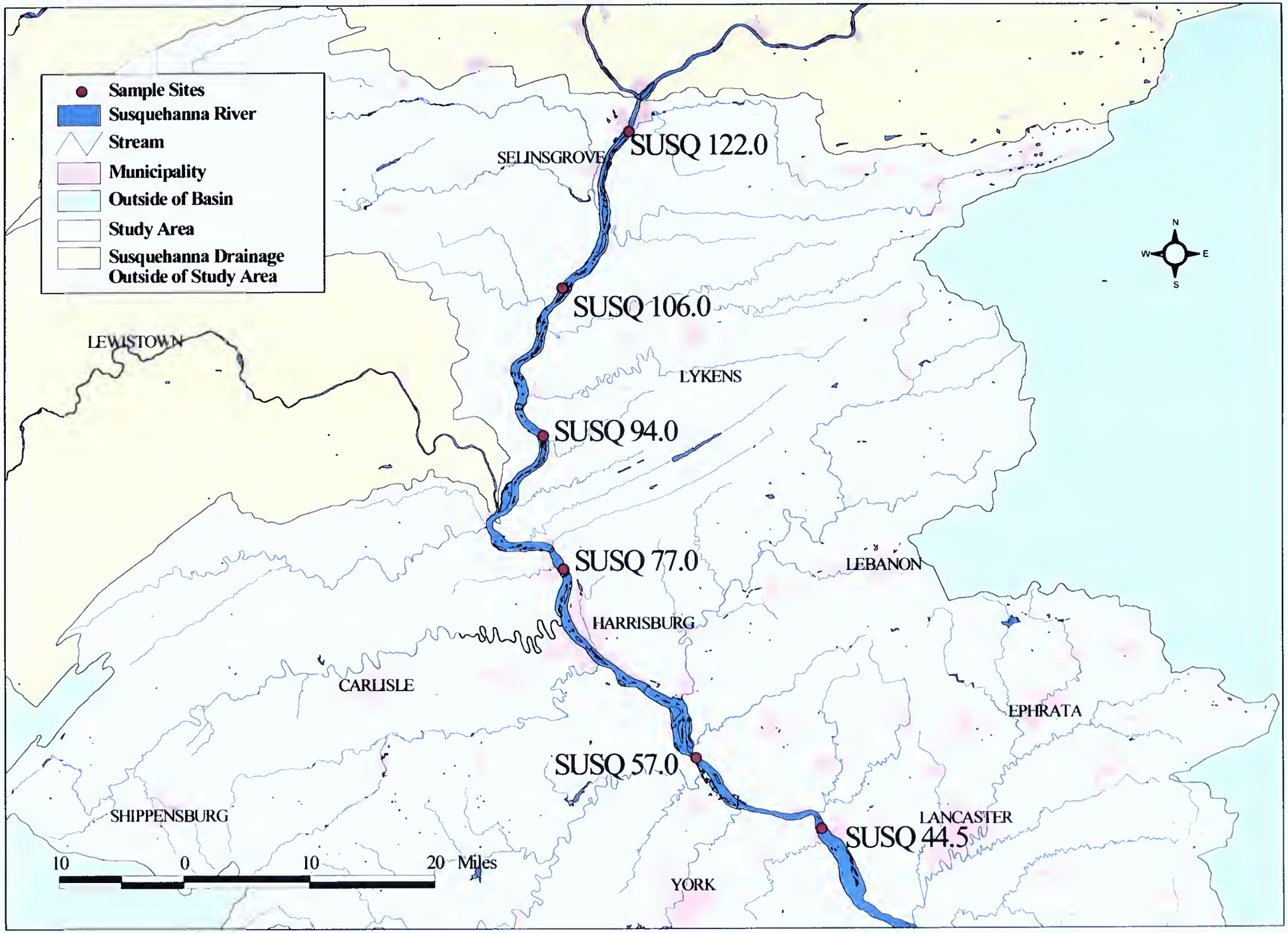


Figure 32. Map of Susquehanna River Sample Sites

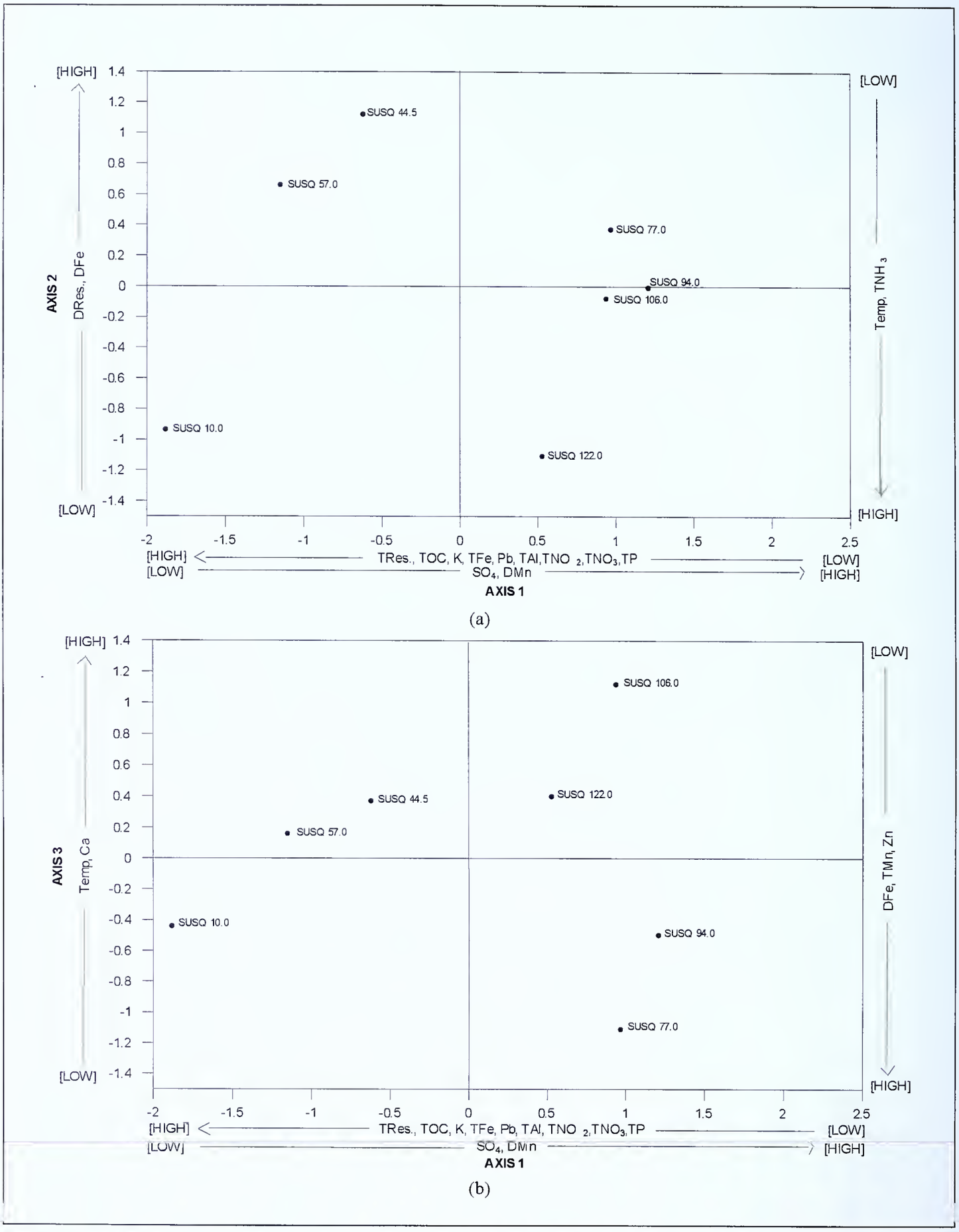
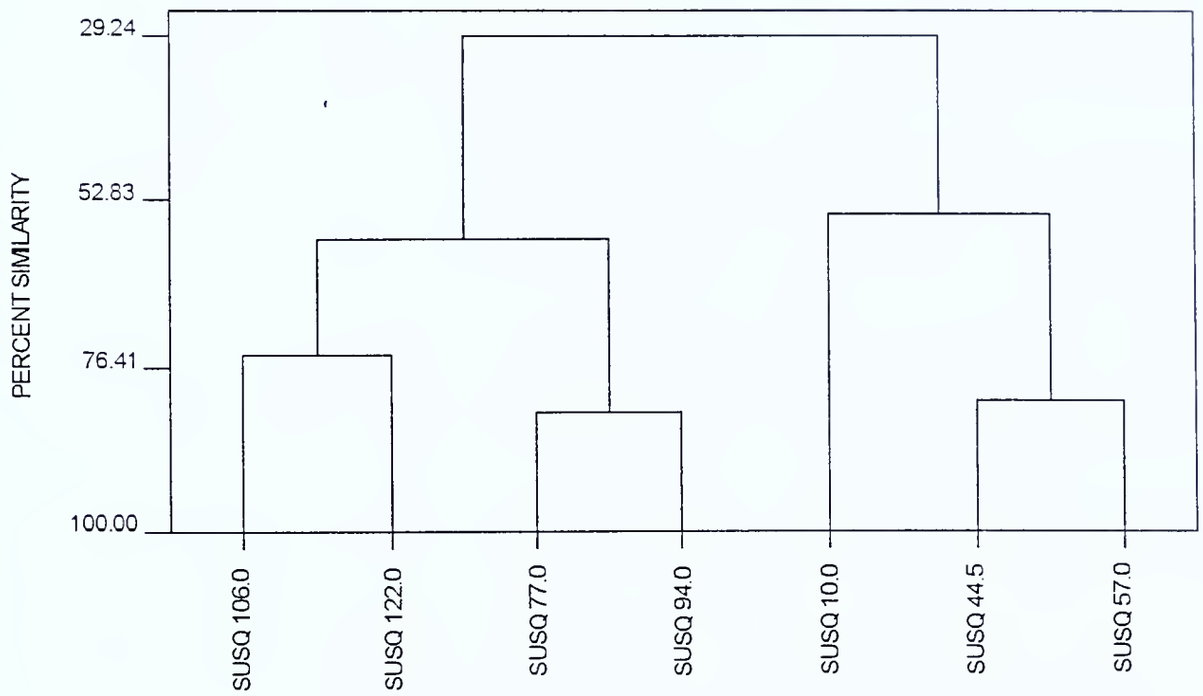


Figure 33. ***Ordination of Susquehanna River Sample Sites Based on Principal Components Analysis of Water Quality*** *((a) PCA Axis 1 Versus PCA Axis 2, and (b) PCA Axis 1 Versus PCA Axis 3)*



Water Quality Variables Identified by PCA and Used to Generate Dendrogram

General Variables	Nutrients	Organic Matter	Ions	Metals
Temp	TNH_3	TOC	Ca	TFe
DRes	TNO_2		K	DFe
TRes	TNO_3		SO_4	TMn
	TP			DMn
				Pb
				Zn
				DAl

Figure 34. Cluster Analysis of Water Quality Parameters That Account for Most of the Variability in Susquehanna River Sample Sites Water Quality Data

Table 22. Summary of Susquehanna River RBP III Habitat Data

	SUSQ 77.0	SUSQ 44.5	SUSQ 57.0	SUSQ 94.0	SUSQ 106.0	SUSQ 122.0
Primary Parameters						
Bottom Substrate	14	16	15	15	11	17
Embeddedness	8	17	15	12	17	17
Velocity/Depth Diversity	13	17	14	17	18	18
Secondary Parameters						
Pool/Riffle Ratio	11	13	7	6	7	7
Pool Quality	14	13	11	11	13	13
Riffle/Run Quality	12	12	5	11	13	11
Channel Alteration	10	12	7	7	14	11
Tertiary Parameters						
Streambank Erosion	7	7	5	3	6	7
Streambank Stability	8	7	7	8	5	8
Streamside Vegetative Cover	5	6	7	7	5	9
Riparian Buffer Zone	4	5	6	5	2	5
Total Habitat Score						
Total Habitat Score	106	125	99	102	111	123
Habitat % of Reference	100	118	93	96	105	116

Table 23. Summary of Susquehanna River RBP III Biological Data

	SUSQ 77.0	SUSQ 44.5	SUSQ 57.0	SUSQ 94.0	SUSQ 106.0	SUSQ 122.0
Raw Data Summary						
Number of Individuals	100	103	105	111	101	114
Percent Shredders	8.0	0.0	41.0	20.7	1.0	1.8
Percent Collector-Gatherers	39.0	53.4	4.8	18.9	9.9	21.9
Percent Filterer-Collectors	22.0	24.3	17.1	4.5	38.6	49.1
Percent Scrapers	26.0	14.6	30.5	50.5	20.8	7.9
Percent Predators	5.0	7.8	6.7	5.4	29.7	19.3
Number of EPT Taxa	10	8	6	13	9	7
Number of EPT Individuals	75	91	34	36	65	75
Metric Scores						
Taxonomic Richness	16	17	16	25	18	15
Diversity Index	3.42	2.78	3.03	3.58	3.43	3.01
Hilsenhoff Biotic Index	4.16	4.48	5.81	4.96	3.40	3.01
EPT Index	10	8	6	13	9	7
Taxonomic Similarity (%)	100.0	26.9	37.9	29.3	29.6	19.6
Trophic Similarity (%)	100.0	83.9	70.0	63.6	60.4	59.7
Percent of Reference						
Taxonomic Richness	100.0	106.3	100.0	156.3	112.5	93.8
Diversity Index	100.0	100.3	104.7	88.6	81.3	88.0
Hilsenhoff Biotic Index	100.0	92.9	71.6	83.8	122.5	138.3
EPT Index	100.0	80.0	60.0	130.0	90.0	70.0
Taxonomic Similarity (%)	100.0	26.9	37.9	29.3	29.6	19.6
Trophic Similarity (%)	100.0	83.9	70.0	63.6	60.4	59.7
Biological Condition Scores						
Taxonomic Richness	6	6	6	6	6	6
Diversity Index	6	6	6	6	6	6
Hilsenhoff Biotic Index	6	6	4	4	6	6
EPT Index	6	4	0	6	6	2
Taxonomic Similarity (%)	6	2	4	2	2	0
Trophic Similarity (%)	6	6	4	4	4	4
Total Biological Score						
Total Biological Score	36	30	24	28	30	24
Biological % of Reference	100	83	67	78	83	67

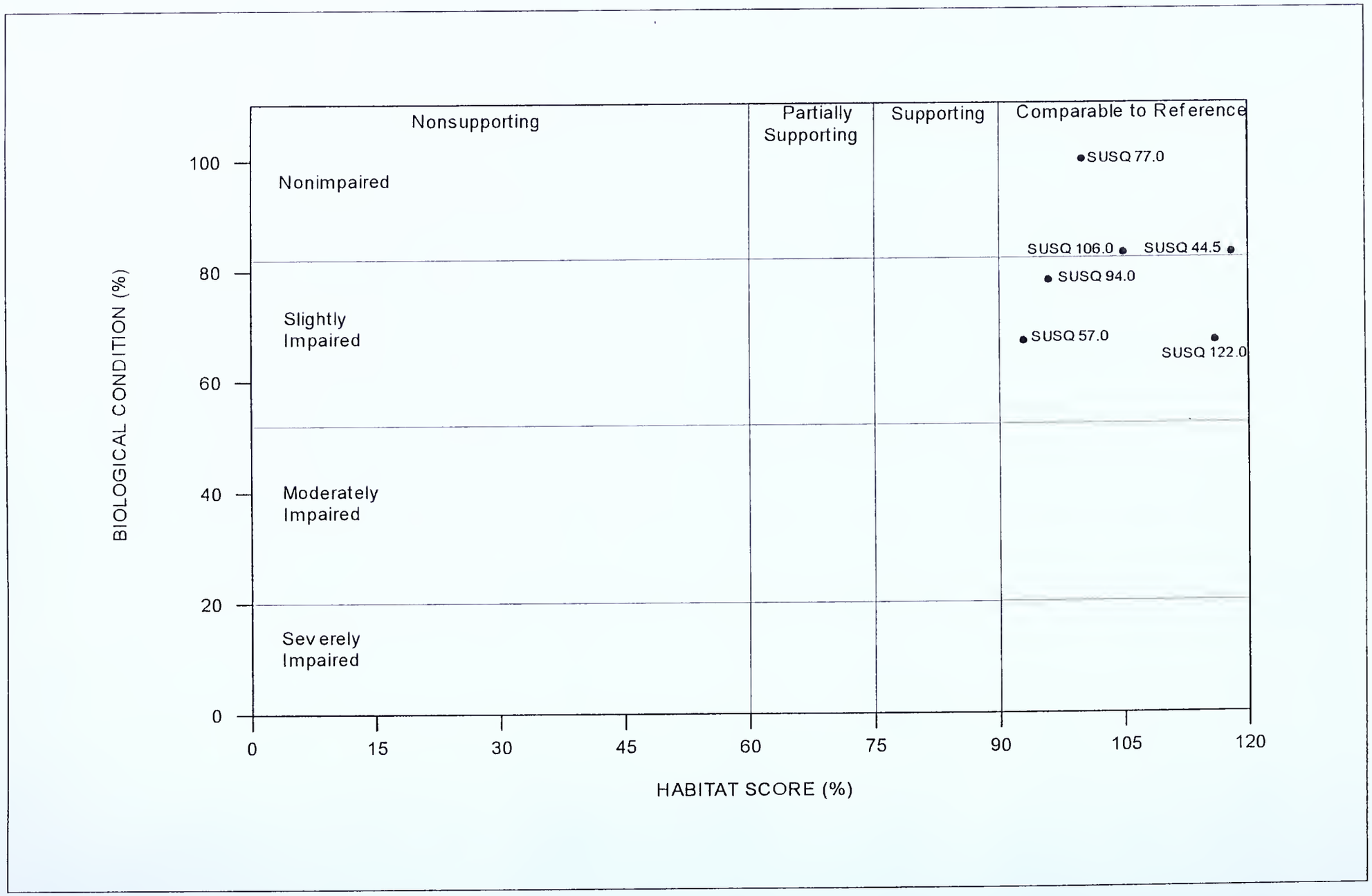


Figure 35. Summary of Susquehanna River Sample Sites RBP III Biological and Habitat Data

BIOASSESSMENT OF STREAMS AND RIVERS

For discussion purposes, the streams in the various reference categories of the Lower Susquehanna Subbasin are further grouped into northern, central, and southern sections. The boundary between the northern and the central section is at the confluence of the Juniata River with the Susquehanna River. The southern section lies entirely within the Northern Piedmont ecoregion, and includes all Maryland sites; East and West Branches of the Conewago Creek mark its upper boundaries The distribution of the sample sites within these categories is outlined at the beginning of each section.

This separation of the subbasin is based on hydrologic unit codes. Within reference area 67a, a definite division exists in water quality between streams located in the northern section and those designated as central streams. (See Figures 17 and 18.) Northern section streams tend to have significantly lower total nitrate, and are lower in ions, especially chloride. They also have higher total phosphorus and zinc values than all the centrally-located streams except Middle Spring (MISP 0.5). Furthermore, the southern section is composed exclusively of streams in the Northern Piedmont Ecoregion (Ecoregion 64). SWAT 2.3 and ECON 0.0 are the only Ecoregion 64 sites not located in the southern section of the subbasin.

Northern Section Streams

Figure 1 (page 2) shows northern section streams and sample sites.

Sample sites located in the northern section are listed below with their reference category designations.

67a	67b
ELKN 0.1	ARMS 0.1
PENN 50.6	EMAH 17.1
WPIN 0.8	EMAH 0.2
	LRLN 0.8
	LSHM 0.8
	MIDL 24.7
	NMHT 0.0
	NMID 0.7
	POWL 0.1
	WMHT 2.2
67cd	**67L**
DEEP 1.2	MHNY 0.3
EPIN 0.1	MIDL 0.7
EPIN 12.7	PENN 30.0
	SHAM 2.7
	SUSQ 94.0
	SUSQ 106.0
	SUSQ 122.0
	WICO 0.3

Shamokin Creek

Little Shamokin Creek joins Shamokin Creek just west of Sunbury. At site LSHM 0.8, Little Shamokin Creek offers habitat comparable to the reference site, and is biologically nonimpaired. The most similar community structure to the 67b reference site also is found at LSHM 0.8. Its Hilsenhoff biotic index reflects the presence of pollution-intolerant genera such as *Centroptilum* (Ephemeroptera: Baetidae), *Isonychia* (Ephemeroptera: Isonychiidae), and *Acroneuria* (Plecoptera: Perlidae).

Below Shamokin Dam, Shamokin Creek flows from the east to join the Susquehanna River. Extensive degradation from acid mine drainage (AMD) has been documented in Shamokin Creek for several decades. Abandoned deep mines are thought to be the principal source of the pollution. Attempts at abatement were begun in the early 1970s (Gannett Fleming Corddry and Carpenter, Inc., 1972). However, the creek continues to suffer from severe AMD pollution. Near its mouth (SHAM 2.7), diagnostic "yellow boy" precipitate is present, and no macroinvertebrates are apparent. Other characteristics of AMD are evident from

water quality analysis: a very low pH, high conductivity, and high concentrations of sulfate, copper, iron, lead, manganese, nickel, zinc, and aluminum.

Penns Creek Watershed

Sample sites located in the Penns Creek Watershed are shown below with their reference category designations.

67a	67b	67L
ELKN 0.1	LRLN 0.8	MIDL 0.7
PENN 50.6	MIDL 24.7	PENN 5.0
WPIN 0.8	NMID 0.7	PENN 30.0

Penns Creek and its tributaries are located in central Pennsylvania. The biological communities of the three sampling sites on Penns Creek demonstrate nonimpairment and the sites have excellent habitat. Two of these sites, PENN 50.6 and PENN 30.0, are reference sites for their respective reference categories. PENN 50.6 has relatively elevated levels of metals (including the highest values for total aluminum, lead, and iron in reference category 67a), but these are attributed to the stream's subterranean origin at Penn's Cave near Centre Hall (McMorran, 1987).

Pine Creek flows west from its headwaters to meet Elk Creek, and then enters Penns Creek at Coburn. Upstream from its confluence with Elk Creek, biological conditions at Pine Creek (WPIN 0.8) are moderately impaired. Seventy-eight percent of the 100-organism subsample consists of Chironomidae (Diptera). Consequently, the Hilsenhoff index score is a considerable 6.10, diversity is low, and the site is not biologically similar to the other northern section 67a sites. In comparison with the other 67a streams, which tend to be highly alkaline and calcium-rich, WPIN 0.8 has low alkalinity, low calcium, and high acidity. Total residuals and zinc are present in elevated concentrations, while sulfate and ion concentrations are low. (Refer to Figure 17.) The primary cause of impairment appears to be habitat degradation from a dam upstream of the site, which negatively impacts substrate, velocity/depth diversity ratio, and pool and riffle quality. WPIN 0.8 receives one of the lowest habitat scores in the reference area. Low nutrient and total organic carbon (TOC) values suggest that neither agricultural runoff nor sewage significantly contributes to stream degradation.

The biological community of Elk Creek above its confluence with Pine Creek (ELKN 0.1) shows nonimpairment. Biological metrics are good to excellent; both the taxonomic richness (21 taxa) and EPT index are greater than that of the reference site. The Hilsenhoff index score is somewhat high at ELKN 0.1, because over half of the macroinvertebrates sampled are Chironomidae. Water quality parameters such as low total nitrate and an elevated lead concentration are somewhat similar to PENN 50.6.

Of the Penns Creek sites, PENN 30.0 is biologically the best quality site, with a Hilsenhoff index of 3.27 and an EPT index of 15. It functions as the reference site for reference category 67L.

Laurel Run enters Penns Creek near Laurelton. Laurel Run at site LRLN 0.8 offers good water quality and better habitat than the reference site. The site has high dissolved oxygen (DO) concentrations with low amounts of ions, nitrite, and ammonia. Site LRLN 0.8 is classified as slightly biologically impaired with low taxonomic similarity to the reference site. However, it also boasts the lowest Hilsenhoff index (0.96) in the entire survey, as well as a high EPT index for the reference category. These metrics are the result of a high density (52 percent) of *Dolophilodes* (Trichoptera: Philopotamidae), a pollution-intolerant filter-feeder.

Middle Creek is the largest tributary to Penns Creek. North Branch Middle Creek enters Middle Creek near Benfer. Biological conditions are slightly impaired at NMID 0.7. Water quality is near the mean for the reference category, and habitat is excellent.

South of Benfer, at site MIDL 24.7, Middle Creek is moderately impaired. Taxonomic richness and EPT index scores are poor. The site has high values for TOC (5.5 mg/L) and total

nitrite. Habitat conditions are excellent. Water quality appears to improve somewhat at the mouth (MIDL 0.7), as the TOC and nitrite concentrations are reduced. However, total iron concentration is much higher than at MIDL 24.7, and TOC remains high relative to other reference category 67L sites. The slightly impaired biological community at MIDL 0.7 exhibits a corresponding improvement, although the habitat conditions decline. While the EPT index remains low, it is much lower at the upstream station; all other scores at MIDL 0.7 are superior to those of MIDL 24.7.

Brezina (1980) and McMorran (1986) found indications of minor water quality degradation in Middle Creek, mostly due to municipal discharges. Water quality analysis suggests that these discharges continue to be a source of biological impairment. Several permitted discharges are located on Middle Creek, including the sewage treatment plants (STPs) of Middlecreek, Franklin, Kreamer, and Middleburg.

Near the confluence of Penns Creek with the Susquehanna River, conditions on Penns Creek continue to be excellent. Site PENN 5.0, adjacent to the airport in Selinsgrove, has the most diverse biota in reference category 67L. Overall, the data collected during this survey indicate that the condition of Penns Creek watershed is comparable to that observed by McMorran (1986).

Mahanoy Creek

Mahanoy Creek is significantly affected by AMD. At site MHNY 0.3, it has the greatest amount of dissolved residuals in the entire survey—894 mg/L. Insoluble coal dust is visible on the riverbed. The large loads of magnesium, sulfate, iron, manganese, nickel, zinc, and aluminum at site MHNY 0.3 also are diagnostic of AMD pollution. Only eight genera from three orders (Trichoptera, Diptera, and Coleoptera) are present. Improvement in water quality since the last survey is doubtful. While the 1986 study lists greater concentrations of metals and six less taxa than are now found at site MHNY 0.3, water quality and biotic indices are similar to Brezina's 1980 survey.

West Mahantango Creek

West Mahantango Creek marks the boundary between Juniata and Snyder Counties. The sample site on West Mahantango Creek (WMHT 2.2) serves as the reference site for reference category 67b. The biological community at WHMT 2.2 has a diversity index of 3.72 and a taxonomic richness of 24 genera. North Branch Mahantango Creek, its tributary, has rather similar water chemistry, but has slightly higher concentrations of TOC, total iron, and total aluminum (Figure 21). The biological community in the North Branch at NMHT 0.0 also is nonimpaired. Little development is present at NMHT 0.0; however, habitat is rated as supporting, rather than excellent, primarily due to degraded habitat conditions associated with streambank erosion.

East Mahantango Creek Watershed

Sample sites located in the East Mahantango Creek Watershed are shown below with their reference category designations.

67b	67cd	67L
EMAH 17.1	DEEP 1.2 EPIN 0.1 EPIN 12.7	EMAH 0.2

East Mahantango Creek flows at the foot of Mahantango Mountain. The lower half forms the boundary between Northumberland and Dauphin Counties. Pine Creek, one of its tributaries, enters East Mahantango Creek at Klingerstown. Biological conditions at station EMAH 17.1, upstream of its Pine Creek confluence, appear to be moderately impaired. The low biological score is mainly due to the predominance of three taxa. Many individuals were collected, but members of Chironomidae, *Isonychia*, and *Hydropsyche* (Trichoptera: Hydropsychidae) compose 81 percent of all specimens. *Isonychia* alone comprise more than one-third of the sample. As

illustrated in Figure 21, water quality is fairly similar to the other sites in the reference category, and habitat is excellent.

Biological conditions at Pine Creek are slightly impaired. EPIN 12.7 has a Hilsenhoff index of 5.91. The site has a low diversity for the reference category, which reflects the large percentage of Chironomidae in the sample. A number of pollution-tolerant genera are found, although only one or two individuals represent each genus. *Viviparus* (Gastropoda: Physidae), *Acroneuria* (Plecoptera: Perlidae), *Leuctra* (Plecoptera: Leuctricidae), *Drunella* (Ephemeroptera: Ephemerellidae), and *Sisyra* (Megaloptera: Sisyridae) are present. Raush Creek, a tributary of Pine Creek, has a Pa. DEP acid mine drainage treatment facility. Water quality at EPIN 12.7 is particularly sulfate-rich, and displays greater than average levels of manganese, magnesium, calcium, hardness, and residuals. The unique water quality for the reference category is clearly illustrated by Figures 25 and 26.

Deep Creek's biological community exhibits nonimpairment about a mile upstream from its confluence with Pine Creek (DEEP 1.2). The Hilsenhoff biotic index is a low 3.30, which describes a community more organic pollution-intolerant than average in the Lower Susquehanna Subbasin. Although water quality appears acceptable, it is clearly influenced by mining activity in the area, and is most similar to EPIN 0.1. Pine Creek carries a greater load of metals than Deep Creek, but levels of metals in Deep Creek are high in comparison with other streams in 67cd. Concentrations of total residuals are the highest in the reference category.

Biological metrics describing the mouth of Pine Creek (EPIN 0.1) are poor to fair, and slight impairment exists. Water quality analysis reveals elevated levels of sulfate, iron, and metals, particularly lead and aluminum. McMorran (1986) ascribes the condition of Pine Creek to AMD pollution.

Downstream on East Mahantango Creek at EMAH 0.2, taxonomic richness and diversity increase. The taxonomic and trophic structures of the biological community are dissimilar to those of the reference site at PENN 30.0. (Heptageniidae [Ephemeroptera] is the dominant family.) Therefore, biological conditions are classified as slightly impaired. Agricultural runoff appears to affect water quality; both sites are nitrate-rich, and EMAH 0.2 has an anomalously high concentration of dissolved phosphorus.

Wiconisco Creek

Wiconisco Creek flows into the Susquehanna River at Millersburg. Lower Wiconisco Creek can be described as recovering from AMD. In 1966, LaBuy (1966) documented that the whole stream was degraded. Brezina (1980) and McMorran (1986) reported recovery in lower reaches, particularly 10 miles below the headwaters and beyond.

Although progress has been made since 1966, signs of slight biological impairment characterize Wiconisco Creek at WICO 0.3. Elevated total iron and sulfate concentrations, as well as trace metals such as aluminum, nickel, and zinc, indicate minor contamination from the AMD-polluted upper reaches.

Armstrong Creek

The combination of water quality parameters present at ARMS 0.1, just north of Halifax, is not representative of its reference category. Values of TOC, total residuals concentration, and dissolved iron are high for reference category 67b. The biological community is moderately impaired. Over half of the macroinvertebrates sampled are *Hydropsyche*, which is somewhat tolerant of organic pollution. Not surprisingly, due to the dominance of *Hydropsyche*, taxonomic similarity to the reference is particularly low. Taxonomic richness and the EPT index are poor also.

Overall, the site's water quality is most comparable to that of the lesser-impaired Swatara Creek at SWAT 39.0 (Figure 22), which seems slightly affected by AMD. Due to excellent habitat conditions at the site and the relatively

undeveloped nature of most of Armstrong Creek's watershed, AMD could possibly be a contributing factor in the impairment at ARMS 0.1.

Powell Creek

Powell Creek enters the Susquehanna River just upstream of the Juniata River. The most notable water quality parameters at site POWL 0.1 are a low concentration of ions, a relatively high concentration of TOC and total residuals for reference region 67b, and the highest dissolved iron concentration in the reference category. Biological conditions at Powell Creek are slightly impaired. Taxonomic similarity to the reference site (WHMT 2.2) is low; *Hydropsyche* and *Baetis* (Ephemeroptera: Baetidae) comprise most of the macroinvertebrate sample.

Susquehanna River in the northern section of the subbasin

The northernmost sample site of this survey (SUSQ 122.0) is located on the Susquehanna River, below Sunbury. The biological community at site SUSQ 122.0 is classified as slightly impaired. Taxonomic similarity to reference and EPT index is low. Forty-one percent of the invertebrates collected are *Chimarra* (Trichoptera: Philopotamidae), a filter-feeder. Water quality parameters do not reveal any significant pollution, although total ammonia and zinc concentrations are slightly elevated. Levels of nutrients, iron, and manganese are low in comparison with other sampling sites on the Susquehanna River.

Approximately 6 miles downstream from the mouth of Mahanoy Creek, the Susquehanna River (SUSQ 106.0) is nonimpaired. Water quality is comparable to SUSQ 122.0, but water quality at SUSQ 106.0 is calcium-rich and low in ammonia and zinc.

The biological community at Halifax (SUSQ 94.0) is slightly impaired. SUSQ 94.0 is the most taxa-rich site sampled on the Susquehanna River. Twenty-five taxa were collected; 13 of these are EPT groups. However, the Hilsenhoff index also is the highest of the Susquehanna River sites, and similarity to the reference is low. Water quality is near the mean for most parameters, with the exception of high sulfate, high dissolved manganese, and low total aluminum.

Central Section Streams

Figure 2 (page 3) shows central section streams and sample sites.

Sample sites located in the central section are listed below with their reference category designations.

64ac	64 L	66
ECON 0.0	SWAT 2.3	MNTN 3.0
67a	**67b**	**67cd**
BEAV 0.6 LTRT 0.1 MISP 0.5 SPRG 0.0 TRDL 0.0	LSWT 0.6 MNDA 0.1 PAXT 0.5 PAXT 8.4 QUIT 0.3 SWAT 39.0 SWAT 56.0	CLRK 3.8 LRLS 0.5 STON 0.4
67L		
CONO 1.3 CONO 51.8 CONO 66.0 SHRM 2.0 SHRM 27.5 SUSQ 77.0 SWAT 21.7 YLBR 3.4 YLBR 35.7		

Sherman Creek

Sherman Creek drains an area of 244 square miles in Perry County. At SHRM 27.5, the biological community experiences slight impairment, as indicated primarily by a low EPT index. Nevertheless, *Isonychia* is the predominant genus, and composes one-third of the macroinvertebrate sample. Total iron concentration is somewhat high.

Close to Loysville, Laurel Run meets Sherman Creek. At site LRLS 0.5, Laurel Run has good

water quality and excellent habitat conditions. The community at LRLS 0.5 suffers from slight biological impairment. Few individuals were collected, and taxonomic richness, the number of EPT individuals, and taxonomic similarity scored low. The cause of impairment is unknown.

Biological metrics downstream on Sherman Creek at site SHRM 2.0 near Duncannon show nonimpairment. The Hilsenhoff biotic index value is 3.59, which is the best after the reference site. Taxonomic similarity to the reference site is only fair, since a number of *Isonychia* and *Ceratopsyche* (Trichoptera: Hydropsychidae) individuals results in a large proportion of collector-gatherers at SHRM 2.0. As shown by Figure 30, water quality is close to that of PENN 5.0.

Clark Creek

DeHart Reservoir, which supplies water to the City of Harrisburg, is an impoundment of Clark Creek. At the mouth of the creek, water quality appears unpolluted, with low concentrations of ions, nitrite, and metals. The macroinvertebrate survey reveals that the nonimpaired biological community at CLRK 3.8 is taxa-rich and diverse (as shown by a diversity index value of 4.21). A number of EPT taxa are present. The biological metrics at this site exceed that of the reference, but habitat conditions receive the lowest score in reference category 67cd.

Stony Creek

Stony Creek flows parallel to Clark Creek. At site STON 0.4, the diverse and fairly pollution-intolerant community is nonimpaired biologically. It serves as the reference site for reference category 67cd. The nutrient-poor water quality and high TOC concentration indicate high productivity at the site.

Paxton Creek

From its upper reaches to its confluence with the Susquehanna River, Paxton Creek is heavily impacted by development and multiple sources of pollution. Upstream at PAXT 8.4, which lies at the Harrisburg city perimeter, biological conditions are moderately impaired. A high Hilsenhoff index value and low diversity are the result of a large percentage (40 percent) of *Stenelmis* (Coleoptera: Elmidae). The EPT index is one of the lowest in the reference area. Habitat is supporting, but water quality is poor, with the highest aluminum and iron concentrations in reference category 67b. Ions and other metals also are present in high concentrations.

Close to its confluence with the Susquehanna River, Paxton Creek flows through Harrisburg. One sample site was located at the Sycamore Street Bridge within the city (PAXT 0.5). There, the stream is concreted into its banks, and storm runoff, effluent discharge, and human refuse are evident. Consistent with these observations, dissolved oxygen is a very low 4.99 mg/L, while high values are recorded for conductivity, hardness, dissolved residuals, ions, iron, manganese, acid, total nitrogen, ammonia, and nitrite. No invertebrates were collected under these nonsupporting conditions.

Conodoguinet Creek Watershed

Sample sites located in the Conodoguinet Creek Watershed are shown below with their reference category designations.

67a	67L
LTRT 0.1	CONO 1.3
MISP 0.5	CONO 28.8
TRDL 0.0	CONO 51.8
	CONO 66.0

Conodoguinet Creek is an important water source for communities in the Cumberland Valley. As the creek flows from Kittatiny Mountain to its confluence with the Susquehanna River near Harrisburg, intense agriculture and development along the lower reaches impact habitat quality.

The Conodoguinet Creek watershed is composed primarily of limestone tributaries, three of which were sampled.

Four sampling sites are located on Conodoguinet Creek. Habitat quality at these sites displays a definite deterioration downstream, corresponding with the increasing development toward the mouth. At CONO 66.0 and CONO 51.8, conditions are supporting. Land use at CONO 66.0 and CONO 51.8 is primarily agricultural, with some residential areas and forest. CONO 28.8 has partially supporting habitat, and CONO 1.3 is nonsupporting. CONO 28.8 at Wolf's Bridge Road is at the northern edge of Carlisle, adjacent to primarily residential property, with some active and former agricultural use. CONO 1.3 is in a residential area; the substrate is poor, the channel is concreted, and human refuse is present. Overall, the assessed sites have a pronounced lack of riffle habitat.

Despite the deterioration of habitat conditions downstream, water quality does not appear to suffer a corresponding degradation. Instead, it remains fairly constant throughout the four sites, which form a conspicuous group in principal components analysis (PCA) of water quality (Figures 29 and 30). General characteristics include a relatively low concentration of metals and sulfate and a high concentration of ions. All sites have the highest total nitrate values in reference category 67L, ranging from 3.55 to 3.95 mg/L.

In contrast, biological conditions vary from site to site. At CONO 66.0, biological impairment is slight. Taxonomic richness is the lowest of the Conodoguinet Creek sites, and a low number of EPT taxa are present. CONO 51.8 is nonimpaired; it is the most taxonomically rich in the reference category, and one of the most similar to the reference site, but it also has the greatest Hilsenhoff value. At CONO 28.8, low similarity values and a low EPT index show that the site is moderately impaired. At the mouth, impairment status is upgraded to slight, mainly through an increase in taxonomic similarity to the reference site.

No single source for the impaired areas of Conodoguinet Creek is apparent. Poor habitat is the probable cause of impairment at CONO 1.3, but the other impaired sites are likely to be affected by both poor quality water and the lack of suitable habitat conditions. There are many permitted discharges on the stream and its tributaries: runoff from urban, suburban, and agricultural areas and problems with municipal discharges have been recorded as a problem by Brezina (1980) and McMorran (1986). Between sites CONO 51.8 and CONO 28.8 alone, NPDES permits are held by several mobile home parks, Sun Oil Co., Conodoguinet Mobile, and the Carlisle Suburban Authority.

Three of the five central 67a sites are located on tributaries (Letort Spring Run, Trindle Spring Run, and Middle Spring Run) in the Conodoguinet Creek Watershed. Central 67a sites tend to have relatively high concentrations of dissolved residuals. These sites have higher chloride, nitrate, and ions than the northern sites, and almost twice the sulfate. Reference category 67a designates streams that flow through limestone; these are often dominated by large numbers of *Gammarus*. In contrast with the Conodoguinet Creek sites, habitat at the tributary sites is excellent.

Middle Spring Run meets Conodoguinet Creek between Middle Spring and Newburg. At MISP 0.5, the stream has a nonimpaired biological community. With the exception of a low number of EPT taxa, MISP 0.5 is very similar to the northern section 67a streams, and even exceeds them in diversity. Levels of dissolved aluminum, zinc, and total phosphorus are higher than other central 67a streams.

Letort Spring Run flows northeast through Carlisle, after which it enters Conodoguinet Creek. The biological community at the Letort Spring Run site (LTRT 0.1) is slightly impaired. Thirty-seven percent of the macroinvertebrates sampled are *Gammarus* (Amphipoda: Gammaridae). Water quality attributes include relatively high acid, high ions, and low dissolved phosphorus.

Trindle Spring Run is classified as moderately impaired at TRDL 0.1. Its total biological conditions score (8) is the lowest in the survey. Seventy-four percent of the biota sampled are *Gammarus*; no EPT individuals are present. The highest Hilsenhoff index of the survey (6.27) is found at Trindle Spring Run. While limestone streams typically have a dominant taxon, this site is an extreme case with only four families: Gammaridae (74 percent); Chironomidae (23 percent); Assellidae (Isopoda) (2 percent); and Simuliidae (1 individual). Neither habitat conditions nor the water quality parameters measured seem to be the obvious cause for impairment. Habitat conditions are excellent, and Trindle Spring Run is a cold-water stream with low total iron and aluminum.

Yellow Breeches Creek

The lower reaches of Yellow Breeches Creek function as the boundary between Cumberland and York Counties. In that area, the stream is surrounded by heavily developed land. Nevertheless, habitat throughout the Yellow Breeches Creek sites is supporting.

YLBR 35.7 is classified as slightly impaired. Its most notable biological metrics are high diversity and taxonomic richness. The stream bottom consists of highly embedded gravel, but an excellent pool/riffle ratio and riffle/run quality support the diverse macroinvertebrate community. Water quality analysis reveals no unacceptable levels of parameters measured.

Mountain Creek is the only stream sampled in Ecoregion 66. It enters Yellow Breeches Creek near Mount Holly Springs. The tributary was sampled at site MNTN 3.0. Although there was no reference site for comparison, biological conditions are nonimpaired, as evidenced by a high diversity index of 4.08 and low Hilsenhoff index value (3.60). Twenty-five taxa were collected, and 16 of these are EPT groups. A number of pollution-intolerant genera are present, including *Epeorus* (Ephemeroptera: Heptagenidae), *Glossosoma* (Trichoptera: Glossosomatidae), *Nigronia* (Megaloptera: Corydalidae), *Paracapnia* (Plecoptera: Capniidae), *Leuctra* (Plecoptera: Leuctridae), *Amphinemura* (Plecoptera: Nemouridae), and *Pteronarcys* (Plecoptera: Pteronarcidae). Habitat is excellent.

At the USGS gaging station on Yellow Breeches Creek, site YLBR 3.4 is moderately biologically impaired. When compared with the upstream site (YLBR 37.5), all of the metrics display degradation. Water quality analysis reveals that levels of total iron, ions, nitrate, and metals are higher than the upstream site. NPDES permitted facilities upstream of YLBR 3.4 include a Pa. Fish & Boat Commission facility, B & W Quality Growers, and PPG Industries.

Swatara Creek Watershed

Sample sites located in the Swatara Creek Watershed are shown below with their reference category designations.

64L	67a
SWAT 2.3	BEAV 0.6 SPRG 0.0
67b	**67L**
LSWT 0.6 MNDA 0.1 QUIT 0.3 SWAT 39.0 SWAT 56.0	SWAT 21.7

Swatara Creek is a major east bank tributary to the Susquehanna River. From its headwaters near Tremont, Swatara Creek flows southwest to its mouth at Middletown. At SWAT 56.0, the biological community is moderately impaired by AMD. High concentrations of total iron, manganese, nickel, zinc, total aluminum, sulfate, and ammonia result in a very low number of individuals (40) collected. Fifty-two percent of these are Empididae (Diptera); only seven other families are present in the sample. Habitat conditions are supporting, with low scores for velocity/depth diversity, pool/riffle ratio, pool quality, and channel alteration.

Downstream at Jonestown, preceding the confluence with Little Swatara Creek (SWAT 39.0), conditions noticeably improve. Biological impairment is slight, with a drop in pollution tolerance and an increase to 15 genera. Amounts of metals such as iron and manganese are still considerable, but are less than half the concentrations found at SWAT 56.0. Habitat is excellent.

Little Swatara Creek at LSWT 0.6 has poor water quality and a moderately impaired biological community slightly better than that found at SWAT 56.0. In addition to a high metal load, nutrients also are present in relatively high concentrations.

At the confluence with Quittapahilla Creek at SWAT 21.7, water quality of Swatara Creek approaches the mean for the reference area, and habitat is supporting. High water conditions prevented the collection of invertebrates. Quittapahilla Creek shows moderate impairment at QUIT 0.3, with 52 percent of the organisms in the sample identified as Amphipoda. Biological metrics are comparable to SWAT 56.0. A substantial load of dissolved residuals, total nitrogen, dissolved nitrate, dissolved phosphorus, iron, and levels of ions and minerals are revealed by water quality analysis. Habitat conditions are supporting; scores for streambank erosion and pool/riffle ratio are low. Agricultural activity surrounds the site. In addition, the Annville Municipal Authority and the Lebanon STP are permitted facilities along Quittapahilla Creek.

Manada Creek flows south toward Hershey. The stream does not continue into the town, but instead enters Swatara Creek near Sand Beach. Biological conditions are slightly impaired at site MNDA 0.1. The EPT index is low, but each EPT taxa present has a low organic pollution tolerance value, as does *Macronychus* (Coleoptera: Elmidae), which also is present. Therefore, the Hilsenhoff index value remains low. Habitat is supporting, and water quality is fair, with very low total and dissolved iron concentrations.

Spring Creek flows across the northern fringe of Hershey. Although water quality is close to the mean for 67a central streams and habitat is excellent, Spring Creek is moderately impaired at its mouth (SPRG 0.1). *Stenelmis* compose nearly 70 percent of the macroinvertebrates, resulting in low diversity, a low EPT index, and considerable dissimilarity to the reference site. Like other 67a streams, Spring Creek is heavily influenced by limestone.

Beaver Creek meets Swatara Creek near Hummelstown. For reference category 67a, Beaver Creek at BEAV 0.6 has low alkalinity, low calcium, and high nickel concentrations. Biological conditions are slightly impaired. Habitat is supporting, but has the lowest scores for channel alteration and embeddedness in the reference category. The biotic index is closest to that of the reference site, but its low EPT index is typical of sites in reference category 67a, and its low taxonomic and trophic similarity to the reference is common for 67a central section streams.

Several miles above the mouth of Swatara Creek at SWAT 2.3, recovery appears to be complete, as demonstrated by nonimpaired biota with the highest diversity in reference category 64L. Water quality is near the mean, although ammonia levels are elevated somewhat. Overall, high levels of ammonia and nutrients indicate that a large part of the Swatara Creek Watershed is probably impacted by sources other than AMD such as fertilizer runoff and sewage. Numerous permitted discharges are located on Swatara Creek and its tributaries.

East Conewago Creek

One site is located on East Conewago Creek (ECON 0.0) in reference category 64ac. East Conewago enters the Susquehanna River below Fredric Lake at Falmouth. Biological conditions are slightly impaired, as demonstrated by a low EPT index and relatively high Hilsenhoff index value. The impairment seems to result from poor water quality related to agricultural activity. For its reference category, ECON 0.0 has high values

for TOC, total nitrate, total phosphorus, and ammonia. In comparison with all the sites assessed, concentrations of total iron, total manganese, and ions are high.

Susquehanna River in the central section of the subbasin

Site SUSQ 77.0 at Fort Hunter serves as the reference for the Susquehanna River sites. The biological community at this site is nonimpaired, and it offers the lowest nutrients and ammonia of the Susquehanna River sites. However, it also has the highest sulfate, dissolved manganese, and zinc concentrations.

Water samples taken from the river at Three Mile Island (SUSQ 57.0) indicate slight impairment. Of the Susquehanna River sites, SUSQ 57.0 has the highest Hilsenhoff index value and fewest EPT taxa. (See Table 25 for Susquehanna River sites biological data.) Poor water quality seems to be the cause of impairment. Nutrients, calcium, potassium, and TOC concentrations are high at SUSQ 57.0. Iron, total aluminum, and lead are present in elevated quantities.

Southern Section Streams

Figure 3 (page 4) shows southern section streams and sample sites.

Sample sites located in the southern section are listed below with their reference category designations.

64ac	64d	64L
BERM 11.0	CCLC 12.2	BERM 1.2
CNWG 1.8	HAMM 0.2	CCLC 0.4
CODO 34.1	KRTZ 1.5	CNTG 0.9
DEER 30.1	LCHK 0.4	CNTG 22.6
EBOC 5.3	LCNT 1.7	CNTG 32.7
LCON 1.5	MIDD 0.2	CNTG 43.9
NBMY 0.0	MILL 0.3	CHCK 3.0
SBCC 1.2	MUDD 0.2	CODO 0.6
SBCD 3.6	SBEV 2.5	CODO 22.4
SBMY 0.0		CODO 33.0
WBOC 4.3		DEER 1.2
		MDDY 3.3
		OCTO 1.0
		PQEA 15.2
		PQEA 3.3
		SBCD 0.4
		SUSQ 44.5
		SUSQ 57.0
		WCON 2.9
		WCON 20.4
		WCON 35.5
		WCON 56.3
		WCON 66.5

Sample sites CNWG 1.8, DEER 1.2, DEER 30.1, and OCTO 1.0 are located in Maryland.

West Conewago Creek Watershed

Sample sites located in the West Conewago Creek Watershed are shown below with their reference category designations.

64ac	64L
BERM 11.0	BERM 1.2
LCON 1.5	WCON 2.9
SBCC 1.2	WCON 20.4
	WCON 35.5
	WCON 56.3
	WCON 66.5

West Conewago Creek enters the Susquehanna River downstream from the mouth of East Conewago Creek. The source of West Conewago Creek is near Pennsylvania's Caledonia State Park, and the watershed extends into Carroll County,

Maryland. All sample sites are located in Pennsylvania.

The combination of biological, habitat and water quality conditions on West Conewago Creek vary greatly from station to station. The two upstream sites, WCON 66.5 and WCON 56.3, have excellent habitat, but the biological community at WCON 66.5 is slightly impaired. At station WCON 35.5, habitat is too poor to support invertebrates. Site WCON 20.4 is nonimpaired with partially supporting habitat, and at WCON 2.9, the biological community is nonimpaired and the habitat is excellent.

Low total nitrate is characteristic of the upper West Conewago sites. Water quality at WCON 66.5, outside of Biglerville, is at the reference category mean for many water quality parameters. Despite excellent habitat and seemingly acceptable water conditions, biological impairment is illustrated by weak indices such as a low EPT index and low taxonomic similarity to the reference site. Ten miles downstream, above the confluence of the South Branch Conewago Creek at WCON 56.3, the most notable water quality parameter is the high dissolved iron concentration. The nonimpaired biological community is representative of reference category 64L.

The South Branch Conewago confluence with Conewago Creek is between New Chester and New Oxford, Pa. The biological community at the South Branch site (SBCC 1.2) shows slight impairment. Key biological metrics include a low EPT index and the highest Hilsenhoff biotic index in reference category 64ac. Water quality is highly alkaline for the reference category, and contains high concentrations of total phosphorus, total iron, ions, nickel, and zinc. The habitat is rated as supporting, but it receives one of the lowest habitat scores in the reference area for its poor pool/riffle ratio and riparian buffer zone.

Upstream of the confluence with Bermudian Creek at station WCON 35.5, the straight channel consists of a silt-, sand-, and clay-lined pool; cobble is the predominant channel substrate at the other three stations. A dam upstream heavily impacts the site; all primary habitat parameters score very low. Human refuse is present. Water quality is rather similar to the nonimpaired sites further downstream and very like that of BERM 1.2 (Figure 14), so degraded habitat appears to be the primary cause of severe impairment. However, a distinct rise in TOC and total residuals is seen from site WCON 56.3. Several mobile home parks, as well as STPs operated by the municipal authorities of East Berlin, Reading, New Oxford, and Hanover, are located on Conewago Creek and its tributaries between WCON 56.3 and 35.5.

Bermudian Creek is located in York and Adams Counties. At the 64ac site BERM 11.0, upstream of the confluence with Latimore Creek, the biological community is slightly impaired, as illustrated by a low EPT index. Water quality is fair, with low nitrate, total iron, and total and dissolved manganese. Ten miles downstream, at BERM 1.2, biological conditions are nonimpaired. Water quality at BERM 1.2 is similar to that found at the lower West Conewago sites. Its most outstanding attribute is a large amount of dissolved residuals.

Sample site WCON 20.4 is close to Manchester. The nonimpaired biological community in West Conewago Creek is taxa rich and has a high EPT index for reference category 64L. However, a predominance of Simuliidae results in a fairly high Hilsenhoff value. In addition to the characteristics of West Conewago downstream sites already outlined, water chemistry exhibits elevated amounts of copper and lead.

Downstream at WCON 2.9, taxonomic richness, the EPT index, and similarity to the reference site are nearly identical to WCON 20.4, but diversity shows a slight increase, while the Hilsenhoff index value significantly decreases. High concentrations of copper and iron are present. Overall, the downstream sites on West Conewago Creek tend to be warmer and have higher levels of TOC, nitrate, and manganese than two upstream sites. With respect to their reference category, they have elevated concentrations of nickel.

Little Conewago Creek meets West Conewago Creek near its confluence with the Susquehanna River. The biological community at LCON 1.5 yielded the most individuals and taxa, giving it highest diversity index in reference category 64ac. Nevertheless, the number of EPT individuals is low compared to the reference site, and LCON 1.5 is classified as slightly impaired. Water quality parameters include high alkalinity, total phosphorus, nickel and various ions.

Codorus Creek Watershed

Sample sites located in the Codorus Creek Watershed are shown below with their reference category designations.

64ac	64L
CODO 34.1 SBCD 3.6	CODO 0.6 CODO 22.4 CODO 33.0 SBCD 0.4

Codorus Creek drains 278 square miles in York County. The stream is an important source for drinking water, recreational use, waste removal, and industrial use. Both degraded habitat and poor water quality seem to limit biological health at the Codorus sites.

Total dissolved solids and metal pollution from industrial waste occur in on the lower 25 miles of Codorus Creek. A linear progression can be seen in the PCA ordination of the Codorus sites located in reference area 64L. Total nitrate concentration rises from 1.9 mg/L at CODO 33.0 to 4.2 mg/L at CODO 0.6, while manganese drops progressively. TOC, sulfate, and ions (especially chloride and sodium) also noticeably increase towards the mouth. Dissolved aluminum concentration is much higher at CODO 0.6 and 22.4. Glatfelter Paper Co. discharges clearly affect Codorus Creek upstream of CODO 22.4. Below the discharge, the stream has an unpleasant odor and is discolored. Other industrial discharges to Codorus Creek include: York International Corp., Lehigh Portland Cement Co., Stone Container Corp., United Defense, Harley-Davidson Inc., and Pfaltzgraff Co.

Upstream of the West Branch Codorus confluence with the main stem (CODO 34.1), biological conditions on Codorus Creek are just slightly impaired. Site CODO 34.1 is located in reference category 64ac, and water quality does not follow the trend for Codorus sites found in reference category 64L. Nitrate, aluminum, and both total and dissolved iron are present in higher concentrations at CODO 34.1 than at the downstream site CODO 33.0. Habitat is rated as excellent, but at the time of sampling, the channel was braided and the stream was not flowing. In comparison with the other Codorus Creek sites, total residuals are very high, and a lack of EPT taxa prevents this site from being classified as nonimpaired.

Downstream of the confluence with the West Branch Codorus, CODO 33.0 is moderately impaired. Site CODO 33.0 has the highest Hilsenhoff index of the entire ecoregion and low taxonomic similarity to the reference site. Habitat is excellent.

South Branch Codorus Creek enters the main stem just outside York. Upstream of its confluence is a primarily commercial/industrial and secondarily residential area on the main stem Codorus Creek. Nonsupporting habitat at this site (CODO 22.4) does not sustain a macroinvertebrate population. The channelized, concreted streambed has a sand/silt bottom, with no riffles. Development has eliminated most streamside vegetative cover. Both woody debris and human refuse are present. Although the water contains high concentrations of dissolved iron and manganese, overall water quality does not seem inferior to that of site CODO 0.6.

South Branch Codorus Creek supports a slightly impaired biological macroinvertebrate community and a nonimpaired community at SBCD 3.6 and SBCD 0.4, respectively. The habitat is only partially supporting at SBCD 3.6, primarily due to channelization of the stream in that area. Ammonia, total iron, and manganese concentrations are elevated, and are comparable to or less than those at CODO 22.4. Within reference category 64ac, the most similar water

chemistry is found at CODO 34.1. Downstream, SBCD 0.4 has the best Hilsenhoff index value and the greatest taxonomic similarity to the reference site in reference category 64L. It resembles CODO 22.4, particularly regarding its higher concentrations of iron and nitrate.

Downstream from the confluence with South Branch Codorus Creek (CODO 0.6), water quality characterized by high total nitrate, TOC, ions, sulfate, and nickel concentrations causes moderate impairment. While all other sites have normal copper and lead values, copper levels at CODO 0.6 double, and lead concentration at 2.7µg/L is more than five times the average value of 0.5µg/L. In contrast, the site's habitat is excellent.

Chickies Creek

The headwaters of Chickies Creek are located near Mount Gretna Heights. The stream flows toward its confluence with the Susquehanna River, south of Marietta. One sample site is located 3 miles from the mouth (CHCK 3.0). At this site, the biological community shows moderate impairment. Biological indices reflect the high *Stenelmis* density (53 percent). Habitat conditions are supporting, but the poor water quality is characterized by high concentrations of total residuals, ammonia, total nitrate, total iron, lead, and nickel. In contrast, concentrations of dissolved iron and aluminum are low. A number of NPDES permitted-discharges are located on Chickies Creek and its tributaries, including discharges from a rest home, mobile home parks, a campground, a vineyard, and several residential developments. The Fuller Co., Raymark Industries, Wissahickon Spring Water Inc., and the Manheim STP also have permitted discharges to Chickies Creek.

Little Chickies Creek is slightly impaired biologically. A predominance of *Stenelmis* is characteristic of site LCHK 0.4. The site is located in a residential and agricultural area, and habitat is only partially supporting. Runoff from farms and lawns appears to be a problem, as indicated by high total residuals, very high total nitrate (12 mg/L), and high dissolved phosphorus.

Kreutz Creek

Kreutz Creek has a drainage area of 34.3 square miles in York County. The biological community at KRTZ 1.5 is slightly impaired, with the low EPT index and taxonomic similarity typical of sites in reference category 64d. Nevertheless, diversity is comparatively high. Habitat is partially supporting; the pool/riffle ratio is poor and channel substrate is embedded in sediment, but the riffle/run quality is excellent. The site is located on a golf course and is channelized. Water quality is characterized by high dissolved oxygen and low TOC concentrations.

Conestoga Creek Watershed

Sample sites located in the Conestoga Creek Watershed are shown below with their reference category designations.

64d	64L
CCLC 12.2	CCLC 0.4
HAMM 0.2	CNTG 0.9
LCNT 1.7	CNTG 22.6
MIDD 0.2	CNTG 32.7
MILL 0.3	CNTG 43.9
MUDD 0.2	

The sites on Conestoga Creek all exhibit slight to moderate biological impairment, and the degree of impairment is primarily dependent on habitat conditions. Unrestricted livestock access to the stream is a serious problem throughout the Conestoga drainage area. PCA shows the Conestoga watershed 64L sites, including all the sites on Conestoga Creek and one site from Cocalico Creek, have similar water quality. (See Figures 13 and 14.) For the reference area, these sites have low dissolved iron concentrations, high amounts of ions and dissolved residuals, and high lead values (all have values exceeding 1.0 µg/L, and the median value is 0.5 µg/L). TOC values range from 3 to 3.6 mg/L, and total nitrate values are in the 6-8 mg/L range. Both the main stem of Conestoga Creek and its tributaries are subject to a multitude of industrial, agricultural, waste removal, and residential discharges.

The Conestoga Creek tributary sites are located in reference category 64d, with the exception of CCLC 0.4 on Cocalico Creek, which is located in 64L. A slightly impaired biological community is present at each tributary sampling station. Characteristic of the 64d sites is high total nitrite, a large percentage of *Stenelmis*, and diversity and Hilsenhoff indices close to that of the reference site. Compared to the reference site, the sites have low EPT indices.

Three sites on Conestoga Creek, CNTG 43.9, CNTG 32.7, and CNTG 22.6 have partially supporting habitat conditions. CNTG 0.9 has excellent habitat. This is the only site sampled on Conestoga Creek where the adjacent land is not completely developed. CNTG 0.9 is the only site that has a cobble substrate; the others have inferior gravel substrates. Human refuse is noticeable at all Conestoga Creek sample sites.

The biological community at CNTG 43.9, near Martindale, is slightly impaired, yet biological conditions are typical of the reference area. CNTG 43.9 has significantly higher total iron, aluminum, and manganese than the other Conestoga watershed sites. The area can be characterized as industrial and agricultural.

Muddy Creek enters Conestoga Creek near Hinkletown. Both habitat and water quality may cause slight impairment at MUDD 0.2. Habitat is partially supporting, and water quality data show low dissolved residuals and total nitrate, but high total nitrite. *Stenelmis* comprises 51 percent of the collected macroinvertebrate fauna. Muddy Creek's low alkalinity and low calcium are unusual for reference area 64d.

Downstream on Conestoga Creek at Brownstown, CNTG 32.7 is moderately impaired. Seventy-five percent of the invertebrates collected from this site are *Stenelmis*. This results in the lowest diversity index in the reference category, as well as the lowest EPT index, and least similarity to reference. Copper, dissolved iron, and acid are present in greater quantities at CNTG 32.7 than at other Conestoga sites. A storm drain empties into Conestoga Creek at this site.

Cocalico Creek flows through Ephrata. Just outside Ephrata, at CCLC 12.2, the slightly impaired biological community has one of lowest *Stenelmis* densities of reference category 64d, but also has low taxonomic richness. Water quality is characterized by low total nitrite, an intermediate amount of dissolved residuals, elevated copper and zinc, and high sodium, chloride, and sulfate. Also, the highest TOC in the reference category, and one of highest dissolved phosphorus values, are found at CCLC 12.2. Not far from the mouth of Cocalico Creek, at Talmage (CCLC 0.4), water quality resembles that of Conestoga Creek. Almost 51 percent of the macroinvertebrates collected at site CCLC 0.4 are *Stenelmis*. CCLC 0.4, like CCLC 12.2 upstream, has only five EPT taxa and supporting habitat, resulting in slight biological impairment.

Middle Creek and Hammer Creek are tributaries to Cocalico Creek. Both flow into Cocalico Creek near Rothsville. Water quality is similar; Hammer (HAMM 0.2) and Middle Creek (MIDD 0.2) sites have lower dissolved phosphorus, sodium, sulfate, and chloride, and higher total iron and lead than most other sites in reference category 64d.

Middle Creek is classified as slightly impaired, but the biotic indices indicate almost moderate impairment at site MIDD 0.2. A small number of individuals are in the macroinvertebrate sample. Over half are Chironomids. Water quality analysis indicates higher total manganese and zinc for the reference area. Habitat is supporting; riffle/run quality receives the lowest score in reference category 64d.

Hammer Creek appears to be of similar biological quality to MIDD 0.2. At HAMM 0.2, Hammer Creek has a large proportion of scrapers (and therefore low trophic similarity to the reference), because almost 39 percent of the individuals collected are *Stenelmis*. However, habitat is only partially supporting. Both MIDD 0.2 and HAMM 0.2 have gravel substrate, but HAMM 0.2 scores slightly worse for many of the habitat parameters, especially for substrate and channel alteration. Dissolved oxygen levels are

low, and total aluminum and copper concentrations are high. The total nitrite concentration is one of highest in the survey.

South of Lancaster, Mill Creek empties into Conestoga Creek. Mill Creek has the best biological metrics after the reference site, yet offers better habitat. Although 46 percent of the macroinvertebrates are *Stenelmis*, MILL 0.3 has the most EPT groups and lowest Hilsenhoff index score in reference area 64d. Concentrations of total nitrate and dissolved phosphorus at this site are a considerable 8.57 mg/L and 0.13 mg/L, respectively. Also present are high concentrations of dissolved residuals and magnesium, but low total iron.

At the USGS gage on Conestoga Creek in Lancaster (CNTG 22.6), biological conditions are usual for 64L, albeit slightly impaired. Water chemistry analysis reveals the highest nitrate in the watershed and low dissolved aluminum values. A dam, channelization, concrete, and a storm drain heavily alter this site, leaving the habitat only partially supporting. The streambanks are unstable with many eroded areas visible.

Little Conestoga Creek meets Conestoga Creek near Safe Harbor. At LCNT 1.7, the slightly impaired biological community is composed of 37 percent *Stenelmis*. Diversity for the reference area is nonetheless high. Water quality appears to be the source of impairment; habitat is excellent, but both dissolved residuals and total nitrate are among the highest in the entire assessment. Several local industries discharge into Little Conestoga Creek and its tributaries.

Biological conditions are slightly impaired near the mouth of Conestoga Creek at Safe Harbor (CNTG 0.9). The highest concentrations of dissolved residuals, calcium, and sodium in reference category 64L are found at CNTG 0.9, resulting in a relatively low taxonomic richness and a low EPT index.

Pequea Creek

Pequea Creek drains 154 square miles in Lancaster County, and it joins the Susquehanna River downstream of Weise Island. Two sample stations are located on Pequea Creek: one at the Route 222 bridge (PQEA 15.2); and one downstream site in Colemansville (PQEA 3.3). Both sites are slightly impaired with partially supporting habitat. Biological metrics are typical of 64L sites, and include low EPT indices and *Stenelmis* as the dominant taxon. PCA ordination shows little variation in water quality between the two sites (Figure 13). Water chemistry is somewhat like that of the Conestoga sites, but Pequea sites have lower TOC and higher amounts of dissolved nitrate. In addition, PQEA 3.3 has one of the highest total residual scores in the survey. Paradise Township and Conestoga Township STPs, Hershey Farms Motel, Crestwood Estates, and the School Districts of Pequea Valley and Penn Manor have NPDES discharges to Pequea Creek.

The confluence of Big Beaver Creek with Pequea Creek occurs near Refton. At SBEV 2.5, biological conditions of Big Beaver Creek are slightly impaired. The site's low EPT index and highly predominant taxa are characteristic of reference category 64d. *Hydropsyche* alone compose almost 40 percent of the sample; *Stenelmis* and *Baetis* together comprise another 42 percent. Nevertheless, SBEV 2.5 has the best biological score and offers some of the best habitat in reference category 64d. Water quality analysis reveals low concentrations of alkalinity, dissolved residuals, total aluminum, and TOC. In contrast, total iron concentration is the highest in the reference category.

Muddy Creek

Sample sites located in Muddy Creek are shown below with their reference category designations.

64L	64ac
MDDY 3.3	NBMY 0.0 SBMY 0.0

The North and South Branches of Muddy Creek meet at Muddy Creek Forks to form the main stem Muddy Creek. Muddy Creek then enters the Susquehanna River near Holtwood. All three streams support nonimpaired biological communities and have excellent habitat at the sample sites.

Water quality analysis from the sample sites on each branch indicate low alkalinity, phosphorus, and TOC. The water also contains lower than average total manganese and is ion-poor. Station SBMY 0.0 is the reference site for reference category 64ac. It has the highest diversity, highest EPT index, and the lowest Hilsenhoff index score for the reference category. Site NMBY 0.0 is the most comparable to site SMBY 0.0.

Good quality water and excellent habitat also are present in the main stem of Muddy Creek at site MDDY 3.3. The site has low concentrations of dissolved ammonia, TOC, ions, and dissolved aluminum. It functions as the reference site for reference category 64L.

Conowingo Creek

Conowingo Creek enters the Susquehanna River above the Conowingo Dam in Cecil County, Md. At CNWG 1.8 on Conowingo Creek, biological metrics show slight impairment. Thirty-three percent of the macroinvertebrate fauna collected are *Baetis*, which has a Hilsenhoff index value of 6. Water chemical parameters are comparable to those found at the East and West Branch Octoraro sites. Low concentrations of acid, total iron, and total manganese, but high total nitrate are present.

Octoraro Creek Watershed

Sample sites located in the Octoraro Creek Watershed are shown below with their reference category designations.

64ac	64L
EBOC 5.3 WBOC 4.3	OCTO 1.0

Octoraro Creek is formed by the confluence of an east and a west branch. The East Branch at EBOC 5.3 on the Chester/Lancaster County boundary displays slight impairment. Fifty-one percent of 100 macroinvertebrate specimens collected are *Optioservus* beetles (Coleoptera: Elmidae), reflected in a percentage of scrapers uncommonly large for reference category 64ac. EBOC 5.3 scores the lowest in the reference area for taxonomic richness, diversity, EPT groups, and taxonomic similarity. The West Branch at WBOC 4.3 appears to be slightly impaired, but has higher biotic indices than EBOC 5.3. Water quality at WBOC 4.3 and EBOC 5.3 is characterized by low acid, total iron, and total manganese, but high nitrate and elevated phosphorus concentrations. Habitat is excellent.

One mile upstream from its confluence with the Susquehanna River (OCTO 0.1), Octoraro Creek's biological conditions are slightly impaired and representative of reference category 64L. Water quality is good except for a high concentration of nitrate. Iron concentration is low for its reference category. The prevalence of nitrate, coupled with low ammonia and iron concentrations throughout Octoraro Creek and its branches, suggests agricultural runoff as a possible source of impairment. All the sites have some adjacent cropland.

Deer Creek

Deer Creek is the southernmost tributary sampled. It drains some 200 square miles in York County, Pa., and Baltimore and Hartford Counties in Maryland. Its confluence with the Susquehanna River lies to the south of Susquehanna State Park.

Both Deer Creek sample sites are located in Maryland.

Habitat quality is excellent, but the biological community is classified as slightly impaired at DEER 30.1. Water quality is characterized by a high concentration of manganese and iron.

Near the mouth, at DEER 1.2, biological conditions are nonimpaired, and habitat is supporting. Nevertheless, the Hilsenhoff biotic index suggests that the biota at DEER 1.2 are slightly more pollution-tolerant than at the upstream site. *Baetis* and *Gammarus* each compose about 30 percent of the sample at this site, while *Isonychia* comprise almost 30 percent of the macroinvertebrate sample at DEER 30.1. Water quality analysis reveals that copper, iron, lead, aluminum, and dissolved ammonia concentrations are higher than at DEER 30.1, and total nitrate is lower.

Susquehanna River in the southern section of the subbasin

The biological community of the Susquehanna River at the Route 30 bridge in Colombia (SUSQ 44.5) is nonimpaired. Almost 46 percent of the macroinvertebrates collected are *Baetis*. Water quality resembles that of site SUSQ 57.0, which has the same ecoregion and subecoregion designation. Both sites are characterized by higher-end values for total nitrite, dissolved nitrate, TOC, and phosphorus, and are potassium and iron rich. However, iron, total aluminum, and lead are present in higher concentrations at the Three Mile Island site (SUSQ 57.0).

Water samples taken at Conowingo Dam (SUSQ 10.0) showed low dissolved residuals, high ammonia, and high nutrient levels. Lead, zinc, total aluminum, and total manganese are present in comparatively high concentrations for the Susquehanna River. SUSQ 10.0 has one of the highest total iron concentrations in the survey.

Summary of Reference Categories

Twenty-eight percent of the 96 sites assessed in the Lower Susquehanna Subbasin support nonimpaired biological communities. Nearly half (49 percent) have slightly impaired biological conditions. Biological conditions are moderately impaired and severely impaired at 18 percent and 4 percent of the sites, respectively. Table 24 summarizes the habitat and biological scores and condition category for each site.

Reference category 64ac

Reference category 64ac sites generally have excellent habitat and fairly uniform biological conditions, as illustrated by Figure 7. The biological communities of these sites are typically impaired; taxa diversity is relatively high, but EPT indices are low. Elevated concentrations of dissolved nitrate and total phosphorus are found at many of the sample sites. Total iron concentrations are generally low, except at sites DEER 30.1, ECON 0.0, and SBCC 1.2.

Reference category 64d

Each site in reference category 64d shows slight biological impairment. Reference category 64d sites tend to have a dominant taxon that exerts considerable influence on biological scores by reducing diversity, taxa richness, and taxonomic and trophic similarity to the reference site. Some of the highest levels of nutrients in the assessment are found at 64d sites.

Reference category 64L

Variability in habitat, water quality, and biological scores is seen in reference category 64L (Figure 15). Of the subecoregion 64d sites (Appendix D) included in this reference category, only one site (CODO 33.0) has excellent habitat. Poor habitat also is found at subecoregion 64a sites WCON 20.4 and WCON 35.5.

Table 24. Summary of the Physical Habitat and Biological Conditions of Sample Sites in the Lower Susquehanna Subbasin

Stream Name	Sample Site	Reference Category	Biological Score			Habitat Score		
			Total Score	Percent of Reference	Condition Category	Total Score	Percent of Reference	Condition Category
S. Branch Muddy Cr.	SBMY 0.0	64ac	36	100	Nonimpaired	122	100	Excellent
Bermudian Cr.	BERM 11.0	64ac	22	61	Slightly impaired	117	96	Excellent
Conowingo Cr.	CNWG 1.8	64ac	24	67	Slightly impaired	118	97	Excellent
Codorus Cr.	CODO 34.1	64ac	28	78	Slightly impaired	127	104	Excellent
Deer Cr.	DEER 30.1	64ac	26	72	Slightly impaired	129	106	Excellent
E. Branch Octoraro	EBOC 5.3	64ac	20	56	Slightly impaired	119	98	Excellent
E. Conewago	ECON 0.0	64ac	26	72	Slightly impaired	120	98	Excellent
Little Conewago Cr.	LCON 1.5	64ac	26	72	Slightly impaired	119	98	Excellent
N. Branch Muddy	NBMY 0.0	64ac	30	83	Nonimpaired	118	97	Excellent
S. Branch Conewago	SBCC 1.2	64ac	26	72	Slightly impaired	106	87	Supporting
S. Branch Codorus	SBCD 3.6	64ac	28	78	Slightly impaired	76	62	Partially supporting
W.Branch Octararo	WBOC 4.3	64ac	28	78	Slightly impaired	121	99	Excellent
Cocalico Cr.	CCLC 12.2	64d	22	61	Slightly impaired	108	82	Supporting
Hammer Cr.	HAMM 0.2	64d	20	56	Slightly impaired	89	67	Partially supporting
Kreutz Cr.	KRTZ 1.5	64d	24	67	Slightly impaired	91	69	Partially supporting
Little Chickies Cr.	LCHK 0.4	64d	22	61	Slightly impaired	87	66	Partially supporting
Little Conestoga Cr.	LCNT 1.7	64d	24	67	Slightly impaired	114	86	Supporting
Middle Cr.	MIDD 0.2	64d	20	56	Slightly impaired	94	71	Partially supporting
Mill Cr.	MILL 0.3	64d	22	61	Slightly impaired	123	93	Excellent
Muddy Cr.	MUDD 0.2	64d	20	56	Slightly impaired	86	65	Partially supporting
Big Beaver Cr.	SBEV 2.5	64d	26	72	Slightly impaired	119	90	Excellent
Muddy Cr.	MDDY 3.3	64L	36	100	Nonimpaired	127	100	Excellent
Bermudian Cr.	BERM 1.2	64L	32	89	Nonimpaired	130	102	Excellent
Cocalico Cr.	CCLC 0.4	64L	20	56	Slightly impaired	105	83	Supporting
Chickies Cr.	CHCK 3.0	64L	16	44	Moderately impaired	104	82	Supporting
Conestoga Cr.	CNTG 0.9	64L	20	56	Slightly impaired	117	92	Excellent
Conestoga Cr.	CNTG 22.6	64L	22	61	Slightly impaired	83	65	Partially supporting
Conestoga Cr.	CNTG 32.7	64L	14	39	Moderately impaired	91	72	Partially supporting
Conestoga Cr.	CNTG 43.9	64L	26	72	Slightly impaired	92	72	Partially supporting
Codorus Cr.	CODO 0.6	64L	14	39	Moderately impaired	130	102	Excellent
Codorus Cr.	CODO 22.4	64L	0	0	Severely impaired	57	45	Nonsupporting
Codorus Cr.	CODO 33.0	64L	18	50	Moderately impaired	134	106	Excellent
Deer Cr.	DEER 1.2	64L	30	83	Nonimpaired	105	83	Supporting
Octoraro Cr.	OCTO 1.0	64L	26	72	Slightly impaired	109	86	Supporting
Pequea Cr.	PQEA 15.2	64L	22	61	Slightly impaired	80	63	Partially supporting
Pequea Cr.	PQEA 3.3	64L	22	61	Slightly impaired	77	61	Partially supporting
S. Branch Codorus	SBCD 0.4	64L	30	83	Nonimpaired	116	91	Excellent
Swatara Cr.	SWAT 2.3	64L	32	89	Nonimpaired	109	86	Supporting
W. Conewago Cr.	WCON 2.9	64L	32	89	Nonimpaired	116	91	Excellent
W. Conewago Cr.	WCON 20.4	64L	30	83	Nonimpaired	80	63	Partially supporting
W. Conewago Cr.	WCON 35.5	64L	0	0	Severely impaired	71	56	Nonsupporting
W. Conewago Cr.	WCON 56.3	64L	30	83	Nonimpaired	120	94	Excellent
W. Conestoga Cr.	WCON 66.5	64L	24	67	Slightly impaired	115	91	Excellent
Mountain Cr.	MNTN 3.0	66	NA	NA	Nonimpaired	124	NA	Excellent
Penns Cr.	PENN 50.6	67a	36	100	Nonimpaired	132	100	Excellent
Beaver Cr.	BEAV 0.6	67a	20	56	Slightly impaired	101	77	Supporting
Elk Cr.	ELKN 0.1	67a	30	83	Nonimpaired	135	102	Excellent
Letort Spring Run	LTRT 0.1	67a	20	56	Slightly impaired	123	93	Excellent

Table 24. Summary of the Physical Habitat and Biological Conditions of Sample Sites in the Lower Susquehanna Subbasin—Continued

Stream Name	Sample Site	Reference Category	Biological Score			Habitat Score		
			Total Score	Percent of Reference	Condition Category	Total Score	Percent of Reference	Condition Category
Middle Spring Run	MISP 0.5	67a	30	83	Nonimpaired	119	90	Excellent
Spring Cr.	SPRG 0.0	67a	14	39	Moderately impaired	107	81	Supporting
Trindle Spring Run	TRDL 0.0	67a	8	22	Moderately impaired	128	97	Excellent
Pine Cr.	WPIN 0.8	67a	14	39	Moderately impaired	105	80	Supporting
W. Mahatango Cr.	WMHT 2.2	67b	36	100	Nonimpaired	121	100	Excellent
Armstrong Cr.	ARMS 0.1	67b	18	50	Moderately impaired	123	102	Excellent
E. Mahantango Cr.	EMAH 17.1	67b	16	44	Moderately impaired	134	111	Excellent
Laurel Run	LRLN 0.8	67b	24	67	Slightly impaired	139	115	Excellent
Little Shamokin Cr.	LSHM 0.8	67b	34	94	Nonimpaired	131	108	Excellent
Little Swatara Cr.	LSWT 0.6	67b	16	44	Moderately impaired	111	92	Excellent
Middle Cr.	MIDL 24.7	67b	14	39	Moderately impaired	130	107	Excellent
Manada Cr.	MNDA 0.1	67b	20	56	Slightly impaired	107	88	Supporting
N. Mahantango Cr.	NMHT 0.0	67b	30	83	Nonimpaired	107	88	Supporting
N. Branch Middle Cr.	NMID 0.7	67b	24	67	Slightly impaired	125	103	Excellent
Paxton Cr.	PAXT 0.5	67b	0	0	Severely impaired	35	29	Nonsupporting
Paxton Cr.	PAXT 8.4	67b	14	39	Moderately impaired	93	77	Supporting
Powell Cr.	POWL 0.1	67b	20	56	Slightly impaired	126	104	Excellent
Quittapahilla Cr.	QUIT 0.3	67b	10	28	Moderately impaired	106	88	Supporting
Swatara Cr.	SWAT 39.0	67b	26	72	Slightly impaired	134	111	Excellent
Swatara Cr.	SWAT 56.0	67b	10	28	Moderately impaired	91	75	Supporting
Stony Cr.	STON 0.4	67cd	36	100	Nonimpaired	132	100	Excellent
Clarks Cr.	CLRK 3.8	67cd	34	94	Nonimpaired	106	80	Supporting
Deep Cr.	DEEP 1.2	67cd	32	89	Nonimpaired	128	97	Excellent
Pine Cr.	EPIN 0.1	67cd	24	67	Slightly impaired	123	93	Excellent
Pine Cr.	EPIN 12.7	67cd	26	72	Slightly impaired	133	101	Excellent
Laurel Run	LRLS 0.5	67cd	22	61	Slightly impaired	129	98	Excellent
Penns Cr	PENN 30.0	67L	36	100	Nonimpaired	135	100	Excellent
Conodoguinet Cr.	CONO 1.3	67L	24	67	Slightly impaired	79	59	Nonsupporting
Conodoguinet Cr.	CONO 28.8	67L	18	50	Moderately impaired	85	63	Partially supporting
Conodoguinet Cr.	CONO 51.8	67L	32	89	Nonimpaired	105	78	Supporting
Conodoguinet Cr.	CONO 66.0	67L	22	61	Slightly impaired	110	81	Supporting
E. Mahantango Cr.	EMAH 0.2	67L	26	72	Slightly impaired	128	95	Excellent
Mahanoy Cr.	MHNY 0.3	67L	16	44	Moderately impaired	130	96	Excellent
Middle Cr.	MIDL 0.7	67L	26	72	Slightly impaired	110	81	Supporting
Penns Cr.	PENN 5.0	67L	32	89	Nonimpaired	129	96	Excellent
Shamokin Cr.	SHAM 2.7	67L	0	0	Severely impaired	100	74	Partially supporting
Shermans Cr.	SHRM 2.0	67L	32	89	Nonimpaired	122	90	Excellent
Shermans Cr.	SHRM 27.5	67L	28	78	Slightly impaired	119	88	Supporting
Swatara Cr.	SWAT 21.7	67L	NA	NA	No samples	107	79	Supporting
Wiconisco Cr.	WICO 0.3	67L	24	67	Slightly impaired	125	93	Excellent
Yellow Breeches Cr.	YLBR 3.4	67L	16	44	Moderately impaired	112	83	Supporting
Yellow Breeches Cr.	YLBR 35.7	67L	28	78	Slightly impaired	110	81	Supporting
Susquehanna River	SUSQ 77.0	67L	36	100	Nonimpaired	106	100	Excellent
Susquehanna River	SUSQ 44.5	64L	30	83	Nonimpaired	125	118	Excellent
Susquehanna River	SUSQ 57.0	67L	24	67	Slightly impaired	99	93	Excellent
Susquehanna River	SUSQ 94.0	67L	28	78	Slightly impaired	102	96	Excellent
Susquehanna River	SUSQ 106.0	67L	30	83	Nonimpaired	111	105	Excellent
Susquehanna River	SUSQ 122.0	67L	24	67	Slightly impaired	123	116	Excellent

Typically, water quality in this reference category has high levels of dissolved phosphorus, TOC, and total iron. On a gross level, this water quality can be separated into two main groups—one consisting primarily of sites in subecoregions 64a and c, and one composed of subecoregion 64d sites. (Refer to Figure 14, the dendrogram produced by cluster analysis.) Dissolved iron concentration is higher in the group made up of mostly 64a and c, and concentrations of total nitrate, lead, and ions are lower than found at the 64d sites.

Reference category 64L sites typically have a very predominant taxon (25 percent dominance or above). *Stenelmis* is common, and is often the dominant genus. This contributes to the characteristic low diversity and large percentage of scrapers of reference category 64L sites.

Reference category 67a

A difference in water quality between the northern and central section 67a streams was noted previously. The streams in the 67a central section generally have water that is highly alkaline, and low in iron, manganese, and aluminum. Northern section streams (and Middle Spring) have lower total nitrate, ions, and higher total phosphorus. Central section streams appear to be more heavily limestone-influenced and have more degraded habitat than northern section streams.

Reference category 67b

Half of the sites on small, noncalcareous valley streams in Ecoregion 67b are moderately to severely impaired. Multiple sources of pollution, mainly AMD, sewage, and agriculture, impact these streams.

Reference category 67cd

The sites assessed in reference category 67cd are either nonimpaired or slightly impaired, and all but one (CLRK 3.8) has excellent habitat (Figure 27). Water is nutrient-poor, with elevated total iron and/or aluminum values at several sites.

Only six sites on small shale or sandstone ridge streams are included in this assessment. Two (on Pine Creek) are impaired from AMD; the prominence of metals in the analysis reflects this.

Reference category 67L

Fairly diverse biota and excellent or supporting habitat are found at most large Ridge and Valley streams. However, these large streams are often subjected to multiple agents of water quality and habitat degradation, and impairment status varies from site to site.

MANAGEMENT IMPLICATIONS

The physical habitat and water quality characteristics of a stream form the foundation upon which its biological community develops. Furthermore, the natural landscape features within a stream's watershed influence these abiotic (non-living) characteristics of the stream, and in turn, the biological community that it supports. Therefore, the biological community of a particular stream or river, in the absence of man's influence, represents the sum of the relationships between the natural landscape features and the physical habitat and water quality conditions of that waterway.

The water quality, physical habitat, and biological data generated in this survey of the streams and rivers in the Lower Susquehanna Subbasin indicate the relationships between the abiotic and biotic conditions of these waterways vary based on ecoregion designation and drainage area size. Statistically significant relationships ($P < 0.05$) observed between the abiotic characteristics and the biological communities of the streams and rivers in the Lower Susquehanna Subbasin are described below. These findings, although based on a relatively small number of observations, are presented as possible subject areas for future research and as management issues to be considered by natural resource managers and policy makers.

Reference Category 64ac, Small Northern Piedmont Upland or Triassic Lowland Streams

Due to the generally excellent habitat found at reference category 64ac sample sites, degradation of water quality appears to be the main source of biological impairment. This inference appears to be supported by the statistical relationship that exists between water chemistry and biological quality. Biological scores of 64ac sites are negatively correlated with total phosphorus, TOC, and sodium concentrations. Clearly, management activities should focus on water quality restoration and protection, particularly through nutrient-reduction efforts.

Reference Category 64d, Small Northern Piedmont Limestone Lowland Streams

In comparison with other reference categories, habitat quality for reference category 64d is poor—only two of the nine sites have excellent habitat conditions (Table 10). Channel alteration has left many of these streams with a poor pool/riffle ratio, and most display a relatively small riparian buffer zone. Water in subecoregion 64d is nutrient-rich; it is characterized by high concentrations of total nitrogen, total nitrite, dissolved phosphorus and calcium.

Analysis reveals few statistically significant relationships in the Northern Piedmont limestone streams. TOC and total manganese are the only chemical water quality parameters with a significant correlation to biological quality.

Both water and habitat qualities in the small limestone streams of the Northern Piedmont have experienced degradation. Although statistical analyses in this survey did not find a significant correlation between habitat and biological condition scores, this may be a result of the rather uniformly degraded habitat quality conditions. Habitat restoration efforts would most likely improve overall conditions of these limestone lowland streams. Many small limestone/dolomite streams throughout Pennsylvania have been subjected to significant instream degradation, particularly from livestock access and mill dam construction.

Reference Category 64L, Large Northern Piedmont Streams

Biological scores of large Piedmont streams show a significant relationship with habitat conditions. Substrate material, embeddedness, velocity/depth ratio, and pool quality are correlated with both habitat and biological scores. The habitat parameters are interrelated. Bottom substrate is correlated to the other individual habitat parameters, except for erosion and pool quality. Gravel is often the substrate in 64L streams, but severely biologically impaired sites (CODO 22.4 and WCON 35.5) have a sand, silt, and clay bottom.

The only water quality parameter significantly related to biological score is potassium. Potassium itself has a positive statistical relationship with chloride, sulfate, lead, and nickel. These ions and metals implicate industrial waste as a possible agent of degradation in reference area 64L.

Management activities in these streams and their watersheds should be directed primarily toward habitat restoration and possibly industrial waste discharges.

Reference Category 67a, Small Limestone Valley Streams in the Central Appalachian Ridge and Valley Ecoregion

Streams in reference category 67a have either excellent or supporting habitat; nonimpairment is restricted to sites with excellent habitat (Figure 19), yet biological scores and habitat scores do not appear to have a significant statistical relationship in this assessment. Furthermore, habitat parameters show relatively little correlation to each other. Existing relationships between habitat parameters primarily focus around riffle/run quality. Riffle/run quality is correlated to substrate, embeddedness, velocity, and pool quality.

Like limestone valley streams of the Northern Piedmont, Appalachian limestone valley streams have often been subject to extensive alteration. Unrestricted livestock access is another problem for many of these streams. Therefore, restoration and maintenance of instream habitat and riparian vegetation are likely to improve biological conditions.

Reference Category 67b, Small Shale or Slate Noncalcareous Valley Streams in the Central Appalachian Ridge and Valley Ecoregion

Habitat scores and biological scores are positively correlated. Habitat parameters also show a greater interdependence than found in other reference categories. A relatively high number of chemical parameters also show significant correlation with both habitat and biological scores.

Both habitat and chemical water quality have a considerable impact upon biological communities of small shale and slate valley streams. Relationships among water chemistry, habitat, and biological quality for reference category 67b also are outlined in the 1997 assessment of the Juniata Subbasin. While the parameter relationships are not identical, the conclusion is the same: management activities should strive to restore and protect instream habitat, riparian vegetation, and water quality of small noncalcareous valley streams.

Reference Category 67cd, Small Sandstone or Shale Ridge Streams in the Central Appalachian Ridge and Valley Ecoregion

Chemical parameters that are significantly correlated with biological health include pH, conductivity, dissolved residuals, calcium, sodium, chloride, and dissolved iron. These parameters suggest AMD as a factor.

Management efforts in reference category 67cd should focus on improvement in water quality in those areas affected by AMD.

Reference Category 67L, Large Central Appalachian Ridge and Valley Streams

A number of chemical parameters, particularly those associated with AMD, have a significant negative correlation with biological score, including total ammonia, magnesium, sodium, potassium, dissolved iron, lead, total manganese, nickel, zinc, and dissolved aluminum.

Due to AMD, MHNY 0.3 and SHAM 2.7 in reference category 67L are vastly different than the other sites. This great difference results in a compression of the remaining sites in the dendrogram of the cluster analysis (Figure 30), and thus tends to obscure their relationships. Management efforts in large Appalachian Ridge and Valley streams should primarily be directed toward restoration of water quality.

CONCLUSIONS

Almost 50 percent of the 96 sites assessed in the Lower Susquehanna Subbasin support biological communities that are classified as slightly impaired. Twenty-eight percent support nonimpaired biological communities. Biological impairment is moderate at 18 percent of the sites, and severe at 4 percent.

It is difficult to compare the results of this assessment with that of McMorran (1986), due to very different methods of macroinvertebrate collection and analysis. Even apparent differences in water quality data do not necessarily show a true change in water condition, since both assessments rely on samples taken at a single point in time, and it is possible that some event may have temporarily altered water chemistry. Comparison of both sets of data with the assessment conducted by Brezina (1980) allows generalizations on the improvement or degradation of Lower Susquehanna Subbasin streams to be somewhat more valid by the addition of time and samples. However, it can be broadly stated that biological conditions are similar to those documented in 1986 and 1980, with improvement occurring in some AMD-impacted stream reaches.

The specific relationships among physical habitat, water quality, and biological conditions of the streams and rivers in the Lower Susquehanna Subbasin appear to vary, based on drainage area size and ecoregion. Some of the water quality and habitat parameters with a significant ($P<0.05$) correlation to biological score include: (1) total phosphorus, TOC, and sodium concentrations in small Piedmont upland and Triassic lowland (reference category 64ac) streams; (2) TOC and total manganese in small Piedmont limestone lowland (reference category 64d) streams; (3) potassium and substrate material, embeddedness, velocity/depth ratio and pool quality in large Piedmont (reference category 64L) streams; (4) dissolved ammonia, total nitrite, calcium, magnesium, sodium, chloride and fluoride and substrate quality, embeddedness, pool quality, channel alteration, riffle/run quality, velocity/depth ratio, and pool/riffle ratio in noncalcareous valley (reference category 67b) streams; (5) pH, conductivity, dissolved residuals, calcium, sodium, chloride, and dissolved iron in small sandstone or shale ridge (reference category 67cd) streams; and (6) total ammonia, magnesium, nickel, zinc, sodium, potassium, dissolved iron, total manganese and dissolved aluminum in large Ridge and Valley (reference category 67L) streams.

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Appendix A

Organic Pollution-Tolerance Values and Functional Feeding Group Designations of Benthic Macroinvertebrate Taxa

Order	Family	Genus	Organic Pollution Tolerance Value	Functional Feeding Group Designation
Coleoptera	Elmidae	*Ancyronyx*	2	CG
		Dubiraphia	6	SC
		Macronychus	2	SC
		Microcylloepus	2	CG
		Optioservus	4	SC
		Ordobrevia	5	SC
		Stenelmis	5	SC
	Gyrinidae	*Dineutis*	4	P
	Hydrophilidae	*Berosus*	5	CG
		Hydrobius	5	P
	Psephenidae	*Psephenus*	4	SC
		Ectopria	5	SC
Diptera	Athericidae	*Atherix*	2	P
	Chironomidae		7	CG
	Dixidae		1	CG
	Empididae	*Hemerodromia*	6	P
	Simuliidae		6	FC
	Tabanidae	*Tabanus*	5	P
	Tipulidae	*Antocha*	3	CG
		Hexatoma	2	P
		Limonia	6	SH
		Tipula	4	SH
Ephemeroptera	Baetidae	*Baetis*	6	CG
		Centroptilum	2	CG
		Pseudocloeon	4	CG
	Caenidae	*Brachycercus*	3	CG
		Caenis	7	CG
	Ephemerellidae	*Drunella*	1	SC
		Ephemerella	1	SC
		Serratella	2	SC
	Ephemeridae	*Ephemera*	2	CG
		Hexagenia	6	CG
	Heptageniidae	*Epeorus*	0	CG
		Heptagenia	4	SC
		Leucrocuta	1	SC
		Stenacron	4	SC
		Stenonema	3	SC
	Isonychiidae	*Isonychia*	2	FC
	Leptophlebiidae	*Leptophlebia*	4	CG
		Paraleptophlebia	1	CG
	Polymitarcidae	*Ephoron*	2	CG
	Potamanthidae	*Anthopotamus*	4	CG
	Siphlonuridae	*Parameletus*	7	CG
		Siphlonurus	7	CG
	Tricorythidae	*Leptohyphes*	4	CG
		Tricorythodes	4	CG
Hemiptera	Veliidae	*Rhagovelia*	8	P

Order	Family	Genus	Organic Pollution Tolerance Value	Functional Feeding Group Designation
Megaloptera	Corydalidae	*Corydalus*	4	P
		Nigronia	2	P
	Sialidae	*Sialis*	4	P
	Sisyridae	*Sisyra*	1	P
Odonata	Coenagrionidae	*Argia*	6	P
		Nehalennia	7	P
	Gomphidae	*Arigomphus*	4	P
		Gomphus	5	P
		Stylogomphus	4	P
Plecoptera	Capniidae	*Paracapnia*	1	SH
	Chloroperlidae	*Alloperla*	0	CG
	Leuctridae	*Leuctra*	0	SH
	Nemouridae	*Amphinemura*	2	SH
	Peltoperlidae	*Peltoperla*	2	SH
	Perlidae	*Acroneuria*	0	P
		Agnetina	2	P
		Eccoptura	2	P
		Neoperla	3	P
		Paragnetina	1	P
		Perlesta	4	P
	Perlodidae	*Cultus*	2	P
	Pteronarcyidae	*Pteronarcys*	0	SH
	Taeniopterygidae	*Strophopteryx*	3	SH
Trichoptera	Brachycentridae	*Brachycentrus*	1	FC
		Micrasema	2	SH
	Glossomatidae	*Glossosoma*	0	SC
	Hydropsychidae	*Ceratopsyche*	4	FC
		Cheumatopsyche	5	FC
		Hydropsyche	4	FC
		Macrostemum	3	FC
		Potamyia	5	FC
	Leptoceridae	*Mystacides*	4	CG
	Philopotamidae	*Chimarra*	4	FC
		Dolophilodes	0	FC
	Polycentropodidae	*Neureclipsis*	7	FC
		Nyctiophylax	5	FC
		Polycentropus	6	FC
	Psychomyiidae	*Lype*	2	CG
	Rhyacophilidae	*Rhyacophila*	1	P
Amphipoda	Gammaridae	*Gammarus*	6	SH
	Talitridae	*Hyalella*	8	SH
Isopoda	Asellidae	*Caecidotea*	8	SH
Decapoda	Cambaridae	*Cambarus*	6	CG
		Orconectes	6	SH
		Procambarus	6	SH

Order	Family	Genus	Organic Pollution Tolerance Value	Functional Feeding Group Designation
Gastropoda	Ancylidae	*Ferrissia*	7	SC
	Lymnaeidae	*Lymnaea*	7	SC
	Physidae	*Physa*	8	SC
		Viviparus	1	
	Planorbidae	*Gyraulus*	6	SC
Pelecypoda	Corbiculidae	*Corbicula*	4	FC
	Sphaeriidae	*Psidium*	8	FC
Hydracarina			7	P
Gnathobdellida	Hirudinidae	*Helobdella*	6	P
Haplotaxida	Naididae	*Nias*	8	CG
	Tubificidae		10	CG
	Lumbriculidae	*Rhynchelmis*	8	CG
Gordioida	Gordiidae	*Gordius*	9	P
Rhynchobdellida	Glossiphoniidae	*Batracobdella*	6	P
Tricladida	Planariidae	*Dugesia*	7	P

Appendix B

Raw Benthic Macroinvertebrate Data From Sample Sites in the Lower Susquehanna Subbasin

Order	Family	Genus	BERM 11.0 64ac	CNWG 1.8 64ac	CODO 34.1 64ac	DEER 30.1 64ac	EBOC 5.3 64ac
Coleoptera	Elmidae	*Ancyronyx*					
		Dubiraphia					
		Macronychus					
		Microcylloepus					
		Optioservus	2		2	1	51
		Ordobrevia					
		Stenelmis	23	10	28		21
	Gyrinidae	*Dineutis*					
	Hydrophilidae	*Berosus*		2			
		Hydrobius					
	Psephenidae	*Psephenus*	8	2	13		2
		Ectopria					
Diptera	Athericidae	*Atherix*					
	Chironomidae		7	7	13	12	2
	Dixidae						
	Empididae	*Hemerodromia*	2		2		
	Simuliidae		2	5		3	
	Tabanidae	*Tabanus*					
	Tipulidae	*Antocha*			5		
		Hexatoma					
		Limonia				1	
		Tipula					
Ephemeroptera	Baetidae	*Baetis*	6	33	4	7	11
		Centroptilum					
		Pseudocloeon				1	
	Caenidae	*Brachycercus*					
		Caenis			1		
	Ephemerellidae	*Drunella*					
		Ephemerella					2
		Serratella					
	Ephemeridae	*Ephemera*					
		Hexagenia					
	Heptageniidae	*Epeorus*					
		Heptagenia			5		
		Leucrocuta					
		Stenacron					
		Stenonema	3	6	4	8	
	Isonychiidae	*Isonychia*	3		6	28	
	Leptophlebiidae	*Leptophlebia*					
		Paraleptophlebia					
	Polymitarcidae	*Ephoron*					
	Potamanthidae	*Anthopotamus*					
	Siphlonuridae	*Parameletus*					
		Siphlonurus					
	Tricorythidae	*Leptohyphes*					
		Tricorythodes			1		
Megaloptera	Corydalidae	*Corydalus*	1	2			
		Nigronia					
	Sialidae	*Sialis*	1		4		
	Sisyridae	*Sisyra*					
Hemiptera	Veliidae	*Rhagovelia*		1			
Odonata	Coenagrionidae	*Argia*					
		Nehalennia					

Order	Family	Genus	BERM 11.0	CNWG 1.8	CODO 34.1	DEER 30.1	EBOC 5.3
			64ac	64ac	64ac	64ac	64ac
	Gomphidae	*Arigomphus*					
		Gomphus				1	
		Stylogomphus					
Plecoptera	Capniidae	*Paracapnia*					
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*		2	1		2
	Nemouridae	*Amphinemura*					
	Peltoperlidae	*Peltoperla*					
	Perlidae	*Acroneuria*		1	1	2	
		Agnetina					
		Eccoptura					
		Neoperla					
		Paragnetina				2	
		Perlesta					
	Perlodidae	*Cultus*					
	Pteronarcyidae	*Pteronarcys*					
	Taeniopterygidae	*Strophopteryx*					
Trichoptera	Brachycentridae	*Brachycentrus*					
		Micrasema					
	Glossomatidae	*Glossosoma*					
	Hydropsychidae	*Ceratopsyche*		10		9	5
		Cheumatopsyche	31		21	15	
		Hydropsyche		19	10	6	4
		Macrostemum					
		Potamyia				4	
	Leptoceridae	*Mystacides*					
	Philopotamidae	*Chimarra*	15				
		Dolophilodes	1				
	Polycentropodidae	*Neureclipsis*					
		Nyctiophylax					
		Polycentropus					
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*					
Amphipoda	Gammaridae	*Gammarus*					
	Talitridae	*Hyalella*					
Isopoda	Asellidae	*Caecidotea*					
Decapoda	Cambaridae	*Cambarus*					
		Orconectes					
		Procambarus					
Gastropoda	Ancylidae	*Ferrissia*					
	Lymnaeidae	*Lymnaea*					
	Physidae	*Physa*					
		Viviparus					
	Planorbidae	*Gyraulus*					
Pelecypoda	Corbiculidae	*Corbicula*					
	Sphaeriidae	*Psidium*					
Hydracarina							
Gnathobdellida	Hirudinidae	*Helobdella*					
Haplotaxida	Naididae	*Nias*					
	Tubificidae						
	Lumbriculidae	*Rhynchelmis*					
Gordioida	Gordiidae	*Gordius*					
Rhynchobdellida	Glossiphoniidae	*Batracobdella*					
Tricladida	Planariidae	*Dugesia*					

Order	Family	Genus	ECON 0.0 64ac	LCON 1.5 64ac	NBMY 0.0 64ac	SBCC 1.2 64ac	SBCD 3.6 64ac
Coleoptera	Elmidae	*Ancyronyx*					
		Dubiraphia					
		Macronychus					
		Microcylloepus					
		Optioservus	1	10			
		Ordobrevia	8	1			1
		Stenelmis	3	30		35	16
	Gyrinidae	*Dineutis*					
	Hydrophilidae	*Berosus*					
		Hydrobius					
	Psephenidae	*Psephenus*	3	11		5	1
		Ectopria					
Diptera	Athericidae	*Atherix*					
	Chironomidae		16	9	1	18	7
	Dixidae						
	Empididae	*Hemerodromia*					
	Simuliidae			13	18	1	2
	Tabanidae	*Tabanus*					
	Tipulidae	*Antocha*		1	6		4
		Hexatoma	1	1			
		Limonia				1	3
		Tipula					
Ephemeroptera	Baetidae	*Baetis*	26	10	17	19	20
		Centroptilum					
		Pseudocloeon			5		
	Caenidae	*Brachycercus*					
		Caenis		1			
	Ephemerellidae	*Drunella*					
		Ephemerella					1
		Serratella					
	Ephemeridae	*Ephemera*					
		Hexagenia					
	Heptageniidae	*Epeorus*			5		
		Heptagenia	11				
		Leucrocuta			2		
		Stenacron					
		Stenonema	34	8	27	8	27
	Isonychiidae	*Isonychia*	11	5	2		2
	Leptophlebiidae	*Leptophlebia*					
		Paraleptophlebia					
	Polymitarcidae	*Ephoron*					
	Potamanthidae	*Anthopotamus*					
	Siphlonuridae	*Parameletus*					
		Siphlonurus					
	Tricorythidae	*Leptohyphes*				2	
		Tricorythodes	1				1
Megaloptera	Corydalidae	*Corydalus*	1	1			
		Nigronia			1		
	Sialidae	*Sialis*		3		2	
	Sisyridae	*Sisyra*					
Hemiptera	Veliidae	*Rhagovelia*		1			
Odonata	Coenagrionidae	*Argia*					
		Nehalennia					

Order	Family	Genus	ECON 0.0	LCON 1.5	NBMY 0.0	SBCC 1.2	SBCD 3.6
			64ac	64ac	64ac	64ac	64ac
	Gomphidae	*Arigomphus*					
		Gomphus			1		
		Stylogomphus					
Plecoptera	Capniidae	*Paracapnia*					
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*					
	Nemouridae	*Amphinemura*					
	Peltoperlidae	*Peltoperla*					
	Perlidae	*Acroneuria*			3		
		Agnetina					
		Eccoptura					
		Neoperla					
		Paragnetina					
		Perlesta					
	Perlodidae	*Cultus*					
	Pteronarcyidae	*Pteronarcys*					
	Taeniopterygidae	*Strophopteryx*					
Trichoptera	Brachycentridae	*Brachycentrus*					
		Micrasema			1		
	Glossomatidae	*Glossosoma*					
	Hydropsychidae	*Ceratopsyche*		7	11		30
		Cheumatopsyche	8	6	5	10	7
		Hydropsyche	1	16		7	
		Macrostemum					
		Potamyia					2
	Leptoceridae	*Mystacides*					
	Philopotamidae	*Chimarra*		1		8	
		Dolophilodes					
	Polycentropodidae	*Neureclipsis*					
		Nyctiophylax					
		Polycentropus					
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*					
Amphipoda	Gammaridae	*Gammarus*	2			2	
	Talitridae	*Hyalella*					
Isopoda	Asellidae	*Caecidotea*				10	
Decapoda	Cambaridae	*Cambarus*					
		Orconectes				1	1
		Procambarus					
Gastropoda	Ancylidae	*Ferrissia*					
	Lymnaeidae	*Lymnaea*					
	Physidae	*Physa*					
		Viviparus					
	Planorbidae	*Gyraulus*					
Pelecypoda	Corbiculidae	*Corbicula*					
	Sphaeriidae	*Psidium*		1			
Hydracarina							
Gnathobdellida	Hirudinidae	*Helobdella*	1			1	
Haplotaxida	Naididae	*Nias*					
	Tubificidae						
	Lumbriculidae	*Rhynchelmis*	1		1		1
Gordioida	Gordiidae	*Gordius*					
Rhynchobdellida	Glossiphoniidae	*Batracobdella*					
Tricladida	Planariidae	*Dugesia*					

Order	Family	Genus	SBMY 0.0	WBOC 4.3	CCLC 12.2	HAMM 0.2	KRTZ 1.5
			64ac	64ac	64d	64d	64d
Coleoptera	Elmidae	*Ancyronyx*					
		Dubiraphia				1	
		Macronychus					
		Microcylloepus					
		Optioservus	2		1		1
		Ordobrevia				2	
		Stenelmis	17	5	30	38	4
	Gyrinidae	*Dineutis*		1			
	Hydrophilidae	*Berosus*					
		Hydrobius					
	Psephenidae	*Psephenus*		3			
		Ectopria					
Diptera	Athericidae	*Atherix*	2				5
	Chironomidae		5	23	3	4	4
	Dixidae						
	Empididae	*Hemerodromia*					
	Simuliidae		2		15	1	14
	Tabanidae	*Tabanus*					
	Tipulidae	*Antocha*		1			1
		Hexatoma					
		Limonia		3			
		Tipula			2	1	
Ephemeroptera	Baetidae	*Baetis*	16	23	2	30	14
		Centroptilum	1				1
		Pseudocloeon	4				
	Caenidae	*Brachycercus*					
		Caenis					
	Ephemerellidae	*Drunella*					
		Ephemerella					
		Serratella					
	Ephemeridae	*Ephemera*					
		Hexagenia					
	Heptageniidae	*Epeorus*	5				
		Heptagenia					
		Leucrocuta	3				
		Stenacron				1	
		Stenonema	11	8	2	6	5
	Isonychiidae	*Isonychia*	4	15			
	Leptophlebiidae	*Leptophlebia*					
		Paraleptophlebia					
	Polymitarcidae	*Ephoron*					
	Potamanthidae	*Anthopotamus*					
	Siphlonuridae	*Parameletus*					
		Siphlonurus					
	Tricorythidae	*Leptohyphes*					
		Tricorythodes		1		8	
Megaloptera	Corydalidae	*Corydalus*	2			1	8
		Nigronia					
	Sialidae	*Sialis*		3			
	Sisyridae	*Sisyra*					
Hemiptera	Veliidae	*Rhagovelia*					
Odonata	Coenagrionidae	*Argia*					
		Nehalennia					

Order	Family	Genus	SBMY 0.0	WBOC 4.3	CCLC 12.2	HAMM 0.2	KRTZ 1.5
			64ac	64ac	64d	64d	64d
	Gomphidae	*Arigomphus*					
		Gomphus					
		Stylogomphus					
Plecoptera	Capniidae	*Paracapnia*					
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*					
	Nemouridae	*Amphinemura*					
	Peltoperlidae	*Peltoperla*					
	Perlidae	*Acroneuria*	7	8			
		Agnetina	5				
		Eccoptura					
		Neoperla					
		Paragnetina		2			
		Perlesta					
	Perlodidae	*Cultus*					
	Pteronarcyidae	*Pteronarcys*					
	Taeniopterygidae	*Strophopteryx*					
Trichoptera	Brachycentridae	*Brachycentrus*	1				
		Micrasema					
	Glossomatidae	*Glossosoma*					
	Hydropsychidae	*Ceratopsyche*	6	16	32	1	10
		Cheumatopsyche	5	7	7		19
		Hydropsyche	2	9	4	3	13
		Macrostemum					
		Potamyia					
	Leptoceridae	*Mystacides*					
	Philopotamidae	*Chimarra*					
		Dolophilodes					
	Polycentropodidae	*Neureclipsis*		1			
		Nyctiophylax					
		Polycentropus					
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*					
Amphipoda	Gammaridae	*Gammarus*					1
	Talitridae	*Hyalella*					
Isopoda	Asellidae	*Caecidotea*					
Decapoda	Cambaridae	*Cambarus*					
		Orconectes					
		Procambarus					
Gastropoda	Ancylidae	*Ferrissia*					
	Lymnaeidae	*Lymnaea*					
	Physidae	*Physa*					
		Viviparus					
	Planorbidae	*Gyraulus*					
Pelecypoda	Corbiculidae	*Corbicula*					
	Sphaeriidae	*Psidium*			2	1	
Hydracarina							
Gnathobdellida	Hirudinidae	*Helobdella*					
Haplotaxida	Naididae	*Nias*					
	Tubificidae						
	Lumbriculidae	*Rhynchelmis*					
Gordioida	Gordiidae	*Gordius*					
Rhynchobdellida	Glossiphoniidae	*Batracobdella*					
Tricladida	Planariidae	*Dugesia*					

Order	Family	Genus	LCHK 0.4	LCNT 1.7	MIDD 0.2	MILL 0.3	MUDD 0.2
			64d	64d	64d	64d	64d
Coleoptera	Elmidae	*Ancyronyx*					
		Dubiraphia					
		Macronychus					
		Microcylloepus					2
		Optioservus	8	1		2	1
		Ordobrevia		7		5	
		Stenelmis	62	44	5	46	53
	Gyrinidae	*Dineutis*					
	Hydrophilidae	*Berosus*					
		Hydrobius					
	Psephenidae	*Psephenus*	1	1			
		Ectopria					
Diptera	Athericidae	*Atherix*					
	Chironomidae		4	13	28	2	21
	Dixidae						
	Empididae	*Hemerodromia*	1				
	Simuliidae		2	1	1		
	Tabanidae	*Tabanus*					
	Tipulidae	*Antocha*					
		Hexatoma					
		Limonia					
		Tipula					
Ephemeroptera	Baetidae	*Baetis*	10	17	1	2	
		Centroptilum			4		
		Pseudocloeon					
	Caenidae	*Brachycercus*					
		Caenis	1				
	Ephemerellidae	*Drunella*					
		Ephemerella					
		Serratella					
	Ephemeridae	*Ephemera*			2		
		Hexagenia					
	Heptageniidae	*Epeorus*					
		Heptagenia					
		Leucrocuta				1	
		Stenacron			1		
		Stenonema		3		5	2
	Isonychiidae	*Isonychia*	1			2	3
	Leptophlebiidae	*Leptophlebia*					
		Paraleptophlebia					
	Polymitarcidae	*Ephoron*					
	Potamanthidae	*Anthopotamus*					
	Siphlonuridae	*Parameletus*					
		Siphlonurus					
	Tricorythidae	*Leptohyphes*					
		Tricorythodes		1		2	
Megaloptera	Corydalidae	*Corydalus*		3			
		Nigronia					1
	Sialidae	*Sialis*					4
	Sisyridae	*Sisyra*					
Hemiptera	Veliidae	*Rhagovelia*		1			
Odonata	Coenagrionidae	*Argia*					1
		Nehalennia					

Order	Family	Genus	LCHK 0.4	LCNT 1.7	MIDD 0.2	MILL 0.3	MUDD 0.2
			64d	64d	64d	64d	64d
	Gomphidae	*Arigomphus*					
		Gomphus					
		Stylogomphus					
Plecoptera	Capniidae	*Paracapnia*					
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*					
	Nemouridae	*Amphinemura*					
	Peltoperlidae	*Peltoperla*					
	Perlidae	*Acroneuria*					
		Agnetina					
		Eccoptura					
		Neoperla					
		Paragnetina					
		Perlesta					
	Perlodidae	*Cultus*					
	Pteronarcyidae	*Pteronarcys*					
	Taeniopterygidae	*Strophopteryx*					
Trichoptera	Brachycentridae	*Brachycentrus*					
		Micrasema					
	Glossomatidae	*Glossosoma*					
	Hydropsychidae	*Ceratopsyche*	9	21		2	
		Cheumatopsyche		2	1	7	11
		Hydropsyche	22	5		22	4
		Macrostemum					
		Potamyia			1		
	Leptoceridae	*Mystacides*					
	Philopotamidae	*Chimarra*	2				1
		Dolophilodes					
	Polycentropodidae	*Neureclipsis*					
		Nyctiophylax					
		Polycentropus					
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*					
Amphipoda	Gammaridae	*Gammarus*	2		7		
	Talitridae	*Hyalella*					
Isopoda	Asellidae	*Caecidotea*					
Decapoda	Cambaridae	*Cambarus*					
		Orconectes					
		Procambarus					
Gastropoda	Ancylidae	*Ferrissia*					
	Lymnaeidae	*Lymnaea*					
	Physidae	*Physa*					
		Viviparus					
	Planorbidae	*Gyraulus*			1		
Pelecypoda	Corbiculidae	*Corbicula*					
	Sphaeriidae	*Psidium*			1		
Hydracarina							
Gnathobdellida	Hirudinidae	*Helobdella*					
Haplotaxida	Naididae	*Nias*					
	Tubificidae				2		
	Lumbriculidae	*Rhynchelmis*					
Gordioida	Gordiidae	*Gordius*					
Rhynchobdellida	Glossiphoniidae	*Batracobdella*					
Tricladida	Planariidae	*Dugesia*				2	

Order	Family	Genus	SBEV 2.5	BERM 1.2	CCLC 0.4	CHCK 3.0	CNTG 0.9
			64d	64L	64L	64L	64L
Coleoptera	Elmidae	*Ancyronyx*					
		Dubiraphia					
		Macronychus					
		Microcylloepus					
		Optioservus	1	2	1	1	1
		Ordobrevia			4		2
		Stenelmis	62	25	57	54	25
	Gyrinidae	*Dineutis*					
	Hydrophilidae	*Berosus*					
		Hydrobius					
	Psephenidae	*Psephenus*				10	1
		Ectopria					
Diptera	Athericidae	*Atherix*					
	Chironomidae		11	4	5	1	5
	Dixidae						
	Empididae	*Hemerodromia*	1				
	Simuliidae		4		12		1
	Tabanidae	*Tabanus*					
	Tipulidae	*Antocha*	1				
		Hexatoma					
		Limonia					
		Tipula			3		
Ephemeroptera	Baetidae	*Baetis*	32	8	2	3	
		Centroptilum	4	9		1	
		Pseudocloeon					
	Caenidae	*Brachycercus*				1	
		Caenis					
	Ephemerellidae	*Drunella*					
		Ephemerella					
		Serratella		5			
	Ephemeridae	*Ephemera*					
		Hexagenia					
	Heptageniidae	*Epeorus*					
		Heptagenia					
		Leucrocuta					
		Stenacron		4			
		Stenonema	2	5	2	7	13
	Isonychiidae	*Isonychia*	1	4			
	Leptophlebiidae	*Leptophlebia*					
		Paraleptophlebia					
	Polymitarcidae	*Ephoron*					
	Potamanthidae	*Anthopotamus*					
	Siphlonuridae	*Parameletus*					
		Siphlonurus		1			
	Tricorythidae	*Leptohyphes*		3			
		Tricorythodes					1
Megaloptera	Corydalidae	*Corydalus*	1	4	1		
		Nigronia					
	Sialidae	*Sialis*					
	Sisyridae	*Sisyra*					
Hemiptera	Veliidae	*Rhagovelia*					
Odonata	Coenagrionidae	*Argia*					
		Nehalennia					

Order	Family	Genus	SBEV 2.5	BERM 1.2	CCLC 0.4	CHCK 3.0	CNTG 0.9
			64d	64L	64L	64L	64L
	Gomphidae	*Arigomphus*					
		Gomphus					
		Stylogomphus					
Plecoptera	Capniidae	*Paracapnia*					
	Chloroperlidae	*Alloperla*			1		
	Leuctridae	*Leuctra*					
	Nemouridae	*Amphinemura*					
	Peltoperlidae	*Peltoperla*					
	Perlidae	*Acroneuria*					
		Agnetina					
		Eccoptura					
		Neoperla					
		Paragnetina					
		Perlesta					
	Perlodidae	*Cultus*					
	Pteronarcyidae	*Pteronarcys*					
	Taeniopterygidae	*Strophopteryx*					
Trichoptera	Brachycentridae	*Brachycentrus*					
		Micrasema					
	Glossomatidae	*Glossosoma*					
	Hydropsychidae	*Ceratopsyche*	7	2		7	6
		Cheumatopsyche	9	12	6		34
		Hydropsyche	89	8	15	10	24
		Macrostemum					
		Potamyia					
	Leptoceridae	*Mystacides*					
	Philopotamidae	*Chimarra*					
		Dolophilodes					
	Polycentropodidae	*Neureclipsis*					
		Nyctiophylax					
		Polycentropus					
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*					
Amphipoda	Gammaridae	*Gammarus*			2	6	
	Talitridae	*Hyalella*					
Isopoda	Asellidae	*Caecidotea*					
Decapoda	Cambaridae	*Cambarus*					
		Orconectes					
		Procambarus					
Gastropoda	Ancylidae	*Ferrissia*					
	Lymnaeidae	*Lymnaea*					
	Physidae	*Physa*					
		Viviparus					
	Planorbidae	*Gyraulus*					
Pelecypoda	Corbiculidae	*Corbicula*					
	Sphaeriidae	*Psidium*			1		
Hydracarina							1
Gnathobdellida	Hirudinidae	*Helobdella*					
Haplotaxida	Naididae	*Nais*					
	Tubificidae						
	Lumbriculidae	*Rhynchelmis*					
Gordioida	Gordiidae	*Gordius*				1	
Rhynchobdellida	Glossiphoniidae	*Batracobdella*					
Tricladida	Planariidae	*Dugesia*					

Order	Family	Genus	CNTG 22.6 64L	CNTG 32.7 64L	CNTG 43.9 64L	CODO 0.6 64L	CODO 33.0 64L
Coleoptera	Elmidae	*Ancyronyx*					
		Dubiraphia		1			
		Macronychus		1			
		Microcylloepus					
		Optioservus		6	1	3	1
		Ordobrevia					1
		Stenelmis	17	90	29	38	
	Gyrinidae	*Dineutis*					
	Hydrophilidae	*Berosus*					
		Hydrobius					
	Psephenidae	*Psephenus*	1	1			
		Ectopria					
Diptera	Athericidae	*Atherix*					
	Chironomidae		16	2	8	1	8
	Dixidae						
	Empididae	*Hemerodromia*		1			35
	Simuliidae			4	9		
	Tabanidae	*Tabanus*					
	Tipulidae	*Antocha*					
		Hexatoma					
		Limonia					
		Tipula					
Ephemeroptera	Baetidae	*Baetis*		2	6	5	9
		Centroptilum	2				
		Pseudocloeon					
	Caenidae	*Brachycercus*					
		Caenis	9				
	Ephemerellidae	*Drunella*					
		Ephemerella					
		Serratella					
	Ephemeridae	*Ephemera*					
		Hexagenia					
	Heptageniidae	*Epeorus*					
		Heptagenia					1
		Leucrocuta					
		Stenacron	27	1		5	
		Stenonema	10		6	3	1
	Isonychiidae	*Isonychia*	1		1		
	Leptophlebiidae	*Leptophlebia*					
		Paraleptophlebia					
	Polymitarcidae	*Ephoron*					
	Potamanthidae	*Anthopotamus*					
	Siphlonuridae	*Parameletus*					
		Siphlonurus					
	Tricorythidae	*Leptohyphes*					
		Tricorythodes		1		2	
Megaloptera	Corydalidae	*Corydalus*					
		Nigronia					
	Sialidae	*Sialis*	2		1	1	
	Sisyridae	*Sisyra*					
Hemiptera	Veliidae	*Rhagovelia*					
Odonata	Coenagrionidae	*Argia*	2				
		Nehalennia					

Order	Family	Genus	CNTG 22.6 64L	CNTG 32.7 64L	CNTG 43.9 64L	CODO 0.6 64L	CODO 33.0 64L
	Gomphidae	*Arigomphus*					
		Gomphus					
		Stylogomphus					
Plecoptera	Capniidae	*Paracapnia*					
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*					2
	Nemouridae	*Amphinemura*					
	Peltoperlidae	*Peltoperla*					
	Perlidae	*Acroneuria*					
		Agnetina					
		Eccoptura					
		Neoperla					
		Paragnetina					
		Perlesta					
	Perlodidae	*Cultus*					
	Pteronarcyidae	*Pteronarcys*					
	Taeniopterygidae	*Strophopteryx*					
Trichoptera	Brachycentridae	*Brachycentrus*					
		Micrasema					
	Glossomatidae	*Glossosoma*					
	Hydropsychidae	*Ceratopsyche*	5		6	4	36
		Cheumatopsyche	2		24		
		Hydropsyche	2		17		
		Macrostemum					
		Potamyia					
	Leptoceridae	*Mystacides*					
	Philopotamidae	*Chimarra*		1			
		Dolophilodes					
	Polycentropodidae	*Neureclipsis*					
		Nyctiophylax					
		Polycentropus					
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*					
Amphipoda	Gammaridae	*Gammarus*	3	2		31	10
	Talitridae	*Hyalella*					
Isopoda	Asellidae	*Caecidotea*					29
Decapoda	Cambaridae	*Cambarus*					
		Orconectes				1	
		Procambarus					
Gastropoda	Ancylidae	*Ferrissia*				7	
	Lymnaeidae	*Lymnaea*		2	2		
	Physidae	*Physa*					
		Viviparus					
	Planorbidae	*Gyraulus*					
Pelecypoda	Corbiculidae	*Corbicula*					
	Sphaeriidae	*Psidium*	1	2	1		
Hydracarina							
Gnathobdellida	Hirudinidae	*Helobdella*		2			
Haplotaxida	Naididae	*Nais*					
	Tubificidae						
	Lumbriculidae	*Rhynchelmis*					
Gordioida	Gordiidae	*Gordius*					
Rhynchobdellida	Glossiphoniidae	*Batracobdella*					
Tricladida	Planariidae	*Dugesia*					

Order	Family	Genus	DEER 1.2 64L	MDDY 3.3 64L	OCTO 1.0 64L	PQEA 15.2 64L	PQEA 3.3 64L
Coleoptera	Elmidae	*Ancyronyx*					
		Dubiraphia					
		Macronychus					
		Microcylloepus					
		Optioservus	1	1			1
		Ordobrevia		1	6		3
		Stenelmis			23	41	50
	Gyrinidae	*Dineutis*					
	Hydrophilidae	*Berosus*					
		Hydrobius					
	Psephenidae	*Psephenus*	1		3		3
		Ectopria					
Diptera	Athericidae	*Atherix*					
	Chironomidae		9	5	2	6	4
	Dixidae						
	Empididae	*Hemerodromia*	1				
	Simuliidae		1	7		2	2
	Tabanidae	*Tabanus*					
	Tipulidae	*Antocha*					
		Hexatoma					
		Limonia				1	
		Tipula					
Ephemeroptera	Baetidae	*Baetis*	34	29	29	3	5
		Centroptilum			4		
		Pseudocloeon		4			
	Caenidae	*Brachycercus*					
		Caenis					
	Ephemerellidae	*Drunella*					
		Ephemerella					
		Serratella	2				
	Ephemeridae	*Ephemera*					
		Hexagenia					
	Heptageniidae	*Epeorus*		2			
		Heptagenia					
		Leucrocuta					
		Stenacron					
		Stenonema	6	3	8	13	26
	Isonychiidae	*Isonychia*	2	2			1
	Leptophlebiidae	*Leptophlebia*					
		Paraleptophlebia					
	Polymitarcidae	*Ephoron*					
	Potamanthidae	*Anthopotamus*					
	Siphlonuridae	*Parameletus*					
		Siphlonurus					
	Tricorythidae	*Leptohyphes*					
		Tricorythodes				2	1
Megaloptera	Corydalidae	*Corydalus*		2	1		
		Nigronia					
	Sialidae	*Sialis*	4				
	Sisyridae	*Sisyra*					
Hemiptera	Veliidae	*Rhagovelia*					
Odonata	Coenagrionidae	*Argia*					
		Nehalennia					

Order	Family	Genus	DEER 1.2	MDDY 3.3	OCTO 1.0	PQEA 15.2	PQEA 3.3
			64L	64L	64L	64L	64L
	Gomphidae	*Arigomphus*					
		Gomphus					
		Stylogomphus					
Plecoptera	Capniidae	*Paracapnia*					
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*					
	Nemouridae	*Amphinemura*					
	Peltoperlidae	*Peltoperla*		2			
	Perlidae	*Acroneuria*	2	1			
		Agnetina					
		Eccoptura					
		Neoperla					
		Paragnetina		5			
		Perlesta		9			
	Perlodidae	*Cultus*					
	Pteronarcyidae	*Pteronarcys*					
	Taeniopterygidae	*Strophopteryx*					
Trichoptera	Brachycentridae	*Brachycentrus*					
		Micrasema					
	Glossomatidae	*Glossosoma*					
	Hydropsychidae	*Ceratopsyche*	12		17	6	7
		Cheumatopsyche	1	8	2	19	
		Hydropsyche	3	9	1	30	7
		Macrostemum					
		Potamyia					
	Leptoceridae	*Mystacides*					
	Philopotamidae	*Chimarra*	1				
		Dolophilodes	1				
	Polycentropodidae	*Neureclipsis*	2		1		
		Nyctiophylax					
		Polycentropus					
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*					
Amphipoda	Gammaridae	*Gammarus*	35		2		2
	Talitridae	*Hyalella*					
Isopoda	Asellidae	*Caecidotea*				1	
Decapoda	Cambaridae	*Cambarus*					
		Orconectes					
		Procambarus					
Gastropoda	Ancylidae	*Ferrissia*					
	Lymnaeidae	*Lymnaea*					
	Physidae	*Physa*					
		Viviparus					
	Planorbidae	*Gyraulus*					
Pelecypoda	Corbiculidae	*Corbicula*			1		
	Sphaeriidae	*Psidium*					
Hydracarina							1
Gnathobdellida	Hirudinidae	*Helobdella*					
Haplotaxida	Naididae	*Nias*					
	Tubificidae						
	Lumbriculidae	*Rhynchelmis*	1				1
Gordioida	Gordiidae	*Gordius*					
Rhynchobdellida	Glossiphoniidae	*Batracobdella*					
Tricladida	Planariidae	*Dugesia*					

Order	Family	Genus	SBCD 0.4 64L	SWAT 2.3 64L	WCON 2.9 64L	WCON 20.4 64L	WCON 56.3 64L
Coleoptera	Elmidae	*Ancyronyx*					
		Dubiraphia					
		Macronychus					
		Microcylloepus					
		Optioservus	1	11		1	6
		Ordobrevia	1	6			
		Stenelmis	1	21	20	2	47
	Gyrinidae	*Dineutis*					
	Hydrophilidae	*Berosus*					
		Hydrobius					
	Psephenidae	*Psephenus*				1	
		Ectopria					
Diptera	Athericidae	*Atherix*					
	Chironomidae		3	18	7	5	7
	Dixidae						
	Empididae	*Hemerodromia*	1		1		
	Simuliidae		3	15	6	43	5
	Tabanidae	*Tabanus*					
	Tipulidae	*Antocha*					
		Hexatoma					
		Limonia					2
		Tipula					
Ephemeroptera	Baetidae	*Baetis*	8	6	11	7	12
		Centroptilum					3
		Pseudocloeon		3	1		
	Caenidae	*Brachycercus*		2		1	
		Caenis			2		4
	Ephemerellidae	*Drunella*					
		Ephemerella					
		Serratella					
	Ephemeridae	*Ephemera*		2			
		Hexagenia					
	Heptageniidae	*Epeorus*					
		Heptagenia		3	1		
		Leucrocuta					
		Stenacron					
		Stenonema	40	10	27	3	1
	Isonychiidae	*Isonychia*	13	4	22	3	13
	Leptophlebiidae	*Leptophlebia*					
		Paraleptophlebia					
	Polymitarcidae	*Ephoron*			7		
	Potamanthidae	*Anthopotamus*			1		
	Siphlonuridae	*Parameletus*					
		Siphlonurus					
	Tricorythidae	*Leptohyphes*					
		Tricorythodes	2				
Megaloptera	Corydalidae	*Corydalus*			4	3	1
		Nigronia	4				
	Sialidae	*Sialis*			1		
	Sisyridae	*Sisyra*					
Hemiptera	Veliidae	*Rhagovelia*					
Odonata	Coenagrionidae	*Argia*					
		Nehalennia					

Order	Family	Genus	SBCD 0.4	SWAT 2.3	WCON 2.9	WCON 20.4	WCON 56.3
			64L	64L	64L	64L	64L
	Gomphidae	*Arigomphus*					
		Gomphus					
		Stylogomphus					
Plecoptera	Capniidae	*Paracapnia*					
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*	1				
	Nemouridae	*Amphinemura*					
	Peltoperlidae	*Peltoperla*					
	Perlidae	*Acroneuria*				1	
		Agnetina					
		Eccoptura					
		Neoperla					
		Paragnetina					
		Perlesta					
	Perlodidae	*Cultus*					
	Pteronarcyidae	*Pteronarcys*					
	Taeniopterygidae	*Strophopteryx*					
Trichoptera	Brachycentridae	*Brachycentrus*					
		Micrasema					
	Glossomatidae	*Glossosoma*					
	Hydropsychidae	*Ceratopsyche*	6	3		2	
		Cheumatopsyche	15	4	30	10	3
		Hydropsyche	14	1	41	5	9
		Macrostemum					
		Potamyia					1
	Leptoceridae	*Mystacides*					
	Philopotamidae	*Chimarra*				10	16
		Dolophilodes					
	Polycentropodidae	*Neureclipsis*				1	
		Nyctiophylax					
		Polycentropus					
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*					
Amphipoda	Gammaridae	*Gammarus*				2	
	Talitridae	*Hyalella*					
Isopoda	Asellidae	*Caecidotea*					
Decapoda	Cambaridae	*Cambarus*					
		Orconectes					
		Procambarus					
Gastropoda	Ancylidae	*Ferrissia*					
	Lymnaeidae	*Lymnaea*					
	Physidae	*Physa*					
		Viviparus					
	Planorbidae	*Gyraulus*					
Pelecypoda	Corbiculidae	*Corbicula*					
	Sphaeriidae	*Psidium*		2	1		
Hydracarina							
Gnathobdellida	Hirudinidae	*Helobdella*					
Haplotaxida	Naididae	*Nais*					
	Tubificidae						
	Lumbriculidae	*Rhynchelmis*					
Gordioida	Gordiidae	*Gordius*					
Rhynchobdellida	Glossiphoniidae	*Batracobdella*					
Tricladida	Planariidae	*Dugesia*					

Order	Family	Genus	WCON 66.5	MNTN 3.0	BEAV 0.6	ELKN 0.1	LTRT 0.1
			64L	66	67a	67a	67a
Coleoptera	Elmidae	*Ancyronyx*					
		Dubiraphia					
		Macronychus					
		Microcylloepus					
		Optioservus	8	1	22	7	3
		Ordobrevia		3			
		Stenelmis	21		39		1
	Gyrinidae	*Dineutis*					
	Hydrophilidae	*Berosus*					
		Hydrobius					
	Psephenidae	*Psephenus*	13	3	18	2	
		Ectopria					
Diptera	Athericidae	*Atherix*					
	Chironomidae		27	14	15	103	17
	Dixidae						
	Empididae	*Hemerodromia*	4	3			
	Simuliidae			10	4	8	4
	Tabanidae	*Tabanus*					
	Tipulidae	*Antocha*		4	1		
		Hexatoma					
		Limonia					
		Tipula			2		
Ephemeroptera	Baetidae	*Baetis*	7	20		11	
		Centroptilum					
		Pseudocloeon					
	Caenidae	*Brachycercus*	7		1		
		Caenis					
	Ephemerellidae	*Drunella*				3	
		Ephemerella					6
		Serratella				1	
	Ephemeridae	*Ephemera*					
		Hexagenia	8				
	Heptageniidae	*Epeorus*		2			
		Heptagenia		14		2	
		Leucrocuta	8				
		Stenacron					
		Stenonema	17	4	1	3	
	Isonychiidae	*Isonychia*		1	4		36
	Leptophlebiidae	*Leptophlebia*		1			
		Paraleptophlebia				4	
	Polymitarcidae	*Ephoron*					
	Potamanthidae	*Anthopotamus*					
	Siphlonuridae	*Parameletus*				1	
		Siphlonurus					
	Tricorythidae	*Leptohyphes*					
		Tricorythodes					
Megaloptera	Corydalidae	*Corydalus*					
		Nigronia		2			
	Sialidae	*Sialis*	3				
	Sisyridae	*Sisyra*					
Hemiptera	Veliidae	*Rhagovelia*					
Odonata	Coenagrionidae	*Argia*	2				
		Nehalennia					

Order	Family	Genus	WCON 66.5	MNTN 3.0	BEAV 0.6	ELKN 0.1	LTRT 0.1
			64L	66	67a	67a	67a
	Gomphidae	*Arigomphus*					
		Gomphus					
		Stylogomphus					
Plecoptera	Capniidae	*Paracapnia*		4			
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*		12			
	Nemouridae	*Amphinemura*		1			
	Peltoperlidae	*Peltoperla*					
	Perlidae	*Acroneuria*		8			
		Agnetina					
		Eccoptura					
		Neoperla					
		Paragnetina		9		1	
		Perlesta					
	Perlodidae	*Cultus*					
	Pteronarcyidae	*Pteronarcys*		1			
	Taeniopterygidae	*Strophopteryx*		3			
Trichoptera	Brachycentridae	*Brachycentrus*					
		Micrasema					
	Glossomatidae	*Glossosoma*		3			
	Hydropsychidae	*Ceratopsyche*	1		4	18	
		Cheumatopsyche	4		6	11	
		Hydropsyche		10	8	1	4
		Macrostemum					
		Potamyia				2	
	Leptoceridae	*Mystacides*					1
	Philopotamidae	*Chimarra*	1	2		1	
		Dolophilodes					
	Polycentropodidae	*Neureclipsis*					
		Nyctiophylax				1	
		Polycentropus					
	Psychomyiidae	*Lype*				2	
	Rhyacophilidae	*Rhyacophila*					
Amphipoda	Gammaridae	*Gammarus*				1	70
	Talitridae	*Hyalella*					
Isopoda	Asellidae	*Caecidotea*	6				30
Decapoda	Cambaridae	*Cambarus*					11
		Orconectes					
		Procambarus					
Gastropoda	Ancylidae	*Ferrissia*					
	Lymnaeidae	*Lymnaea*					
	Physidae	*Physa*					
		Viviparus					
	Planorbidae	*Gyraulus*					4
Pelecypoda	Corbiculidae	*Corbicula*					
	Sphaeriidae	*Psidium*					2
Hydracarina						1	1
Gnathobdellida	Hirudinidae	*Helobdella*					
Haplotaxida	Naididae	*Nais*					
	Tubificidae						
	Lumbriculidae	*Rhynchelmis*					
Gordioida	Gordiidae	*Gordius*					
Rhynchobdellida	Glossiphoniidae	*Batracobdella*		1			
Tricladida	Planariidae	*Dugesia*					

Order	Family	Genus	MISP 0.5	PENN 50.6	SPRG 0.0	TRDL 0.0	WPIN 0.8
			67a	67a	67a	67a	67a
Coleoptera	Elmidae	*Ancyronyx*					
		Dubiraphia					
		Macronychus					
		Microcylloepus					
		Optioservus	15	4	2		12
		Ordobrevia	2				
		Stenelmis	14	4	75		
	Gyrinidae	*Dineutis*					
	Hydrophilidae	*Berosus*					
		Hydrobius					
	Psephenidae	*Psephenus*		2	1		
		Ectopria			1		
Diptera	Athericidae	*Atherix*		2			
	Chironomidae		31	18	3	33	181
	Dixidae						
	Empididae	*Hemerodromia*					2
	Simuliidae		5			1	3
	Tabanidae	*Tabanus*					1
	Tipulidae	*Antocha*	5				
		Hexatoma					1
		Limonia	1				
		Tipula		2			1
Ephemeroptera	Baetidae	*Baetis*	15	13			
		Centroptilum					
		Pseudocloeon					
	Caenidae	*Brachycercus*					
		Caenis					
	Ephemerellidae	*Drunella*					18
		Ephemerella					1
		Serratella					
	Ephemeridae	*Ephemera*		1			
		Hexagenia					
	Heptageniidae	*Epeorus*					
		Heptagenia					
		Leucrocuta					
		Stenacron					
		Stenonema		1			1
	Isonychiidae	*Isonychia*					
	Leptophlebiidae	*Leptophlebia*					
		Paraleptophlebia		1			
	Polymitarcidae	*Ephoron*					
	Potamanthidae	*Anthopotamus*					
	Siphlonuridae	*Parameletus*		2			
		Siphlonurus					
	Tricorythidae	*Leptohyphes*					
		Tricorythodes	1	1	11		
Megaloptera	Corydalidae	*Corydalus*					
		Nigronia					3
	Sialidae	*Sialis*					
	Sisyridae	*Sisyra*					
Hemiptera	Veliidae	*Rhagovelia*					
Odonata	Coenagrionidae	*Argia*					
		Nehalennia					

Order	Family	Genus	MISP 0.5	PENN 50.6	SPRG 0.0	TRDL 0.0	WPIN 0.8
			67a	67a	67a	67a	67a
	Gomphidae	*Arigomphus*					
		Gomphus					
		Stylogomphus					
Plecoptera	Capniidae	*Paracapnia*					1
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*					
	Nemouridae	*Amphinemura*					
	Peltoperlidae	*Peltoperla*					
	Perlidae	*Acroneuria*		1			
		Agnetina		1			
		Eccoptura					
		Neoperla					
		Paragnetina					
		Perlesta					
	Perlodidae	*Cultus*					
	Pteronarcyidae	*Pteronarcys*					
	Taeniopterygidae	*Strophopteryx*					
Trichoptera	Brachycentridae	*Brachycentrus*					
		Micrasema					
	Glossomatidae	*Glossosoma*	1				
	Hydropsychidae	*Ceratopsyche*	21	71			1
		Cheumatopsyche	5		1		
		Hydropsyche	3				
		Macrostemum					
		Potamyia					
	Leptoceridae	*Mystacides*					
	Philopotamidae	*Chimarra*	2				
		Dolophilodes		2			
	Polycentropodidae	*Neureclipsis*					
		Nyctiophylax					
		Polycentropus					
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*					2
Amphipoda	Gammaridae	*Gammarus*		8	6	105	4
	Talitridae	*Hyalella*	1				
Isopoda	Asellidae	*Caecidotea*	4		7	3	
Decapoda	Cambaridae	*Cambarus*	1				
		Orconectes					
		Procambarus		2			
Gastropoda	Ancylidae	*Ferrissia*					
	Lymnaeidae	*Lymnaea*					
	Physidae	*Physa*					
		Viviparus					
	Planorbidae	*Gyraulus*					
Pelecypoda	Corbiculidae	*Corbicula*					
	Sphaeriidae	*Psidium*					
Hydracarina							
Gnathobdellida	Hirudinidae	*Helobdella*					
Haplotaxida	Naididae	*Nais*					
	Tubificidae						
	Lumbriculidae	*Rhynchelmis*		2	1		
Gordioida	Gordiidae	*Gordius*	1				
Rhynchobdellida	Glossiphoniidae	*Batracobdella*					
Tricladida	Planariidae	*Dugesia*					

Order	Family	Genus	ARMS 0.1	EMAH 17.1	LRLN 0.8	LSWT 0.6	LSHM 0.8
			67b	67b	67b	67b	67b
Coleoptera	Elmidae	*Ancyronyx*					
		Dubiraphia					
		Macronychus					
		Microcylloepus					
		Optioservus	5			4	
		Ordobrevia	5				
		Stenelmis	1	8		29	4
	Gyrinidae	*Dineutis*					
	Hydrophilidae	*Berosus*	5				
		Hydrobius					
	Psephenidae	*Psephenus*	1			2	23
		Ectopria					
Diptera	Athericidae	*Atherix*		15			25
	Chironomidae		1	42	1	36	7
	Dixidae						
	Empididae	*Hemerodromia*					
	Simuliidae					4	
	Tabanidae	*Tabanus*					
	Tipulidae	*Antocha*	1				
		Hexatoma			2		
		Limonia					
		Tipula					1
Ephemeroptera	Baetidae	*Baetis*	3	21	3	10	11
		Centroptilum				2	
		Pseudocloeon				1	
	Caenidae	*Brachycercus*					
		Caenis					
	Ephemerellidae	*Drunella*					
		Ephemerella					
		Serratella					
	Ephemeridae	*Ephemera*					
		Hexagenia					
	Heptageniidae	*Epeorus*					1
		Heptagenia	3	21			
		Leucrocuta					
		Stenacron					
		Stenonema	3		2	2	
	Isonychiidae	*Isonychia*	10	122	3		28
	Leptophlebiidae	*Leptophlebia*					
		Paraleptophlebia					
	Polymitarcidae	*Ephoron*				1	
	Potamanthidae	*Anthopotamus*					
	Siphlonuridae	*Parameletus*					
		Siphlonurus					
	Tricorythidae	*Leptohyphes*					
		Tricorythodes				1	
Megaloptera	Corydalidae	*Corydalus*		4			1
		Nigronia			2		1
	Sialidae	*Sialis*					
	Sisyridae	*Sisyra*					
Hemiptera	Veliidae	*Rhagovelia*					
Odonata	Coenagrionidae	*Argia*					
		Nehalennia					

Order	Family	Genus	ARMS 0.1	EMAH 17.1	LRLN 0.8	LSWT 0.6	LSHM 0.8
			67b	67b	67b	67b	67b
	Gomphidae	*Arigomphus*			4		
		Gomphus					
		Stylogomphus					
Plecoptera	Capniidae	*Paracapnia*					
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*	1		1		
	Nemouridae	*Amphinemura*					
	Peltoperlidae	*Peltoperla*			1		
	Perlidae	*Acroneuria*			10		2
		Agnetina					
		Eccoptura					
		Neoperla					
		Paragnetina		1			2
		Perlesta	11				
	Perlodidae	*Cultus*					
	Pteronarcyidae	*Pteronarcys*			6		
	Taeniopterygidae	*Strophopteryx*					
Trichoptera	Brachycentridae	*Brachycentrus*					
		Micrasema					
	Glossomatidae	*Glossosoma*					
	Hydropsychidae	*Ceratopsyche*			1	4	25
		Cheumatopsyche					3
		Hydropsyche	51	95			
		Macrostemum			19		
		Potamyia					2
	Leptoceridae	*Mystacides*					
	Philopotamidae	*Chimarra*		2			8
		Dolophilodes			72		
	Polycentropodidae	*Neureclipsis*					
		Nyctiophylax					
		Polycentropus					
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*			12		
Amphipoda	Gammaridae	*Gammarus*					
	Talitridae	*Hyalella*					
Isopoda	Asellidae	*Caecidotea*					
Decapoda	Cambaridae	*Cambarus*					
		Orconectes					
		Procambarus					
Gastropoda	Ancylidae	*Ferrissia*					
	Lymnaeidae	*Lymnaea*					
	Physidae	*Physa*					
		Viviparus					
	Planorbidae	*Gyraulus*					
Pelecypoda	Corbiculidae	*Corbicula*					
	Sphaeriidae	*Psidium*				4	
Hydracarina							
Gnathobdellida	Hirudinidae	*Helobdella*					
Haplotaxida	Naididae	*Nias*		1			
	Tubificidae						
	Lumbriculidae	*Rhynchelmis*					
Gordioida	Gordiidae	*Gordius*					
Rhynchobdellida	Glossiphoniidae	*Batracobdella*					
Tricladida	Planariidae	*Dugesia*					

Order	Family	Genus	MIDL 24.7	MNDA 0.1	NMHT 0.0	NMID 0.7	PAXT 8.4
			67b	67b	67b	67b	67b
Coleoptera	Elmidae	*Ancyronyx*					
		Dubiraphia					
		Macronychus		14			
		Microcylloepus					
		Optioservus	2	10	9	13	5
		Ordobrevia					
		Stenelmis	8	23	14	3	41
	Gyrinidae	*Dineutis*					
	Hydrophilidae	*Berosus*					
		Hydrobius					
	Psephenidae	*Psephenus*		10	13	4	6
		Ectopria					
Diptera	Athericidae	*Atherix*					
	Chironomidae		12	1	49	47	14
	Dixidae						
	Empididae	*Hemerodromia*				3	
	Simuliidae		11			1	1
	Tabanidae	*Tabanus*					
	Tipulidae	*Antocha*			4	1	
		Hexatoma					
		Limonia	8		13		
		Tipula			1		
Ephemeroptera	Baetidae	*Baetis*			30	3	11
		Centroptilum		19			
		Pseudocloeon					
	Caenidae	*Brachycercus*		6	2		
		Caenis				1	
	Ephemerellidae	*Drunella*					
		Ephemerella					
		Serratella					
	Ephemeridae	*Ephemera*					
		Hexagenia					
	Heptageniidae	*Epeorus*					
		Heptagenia			5		
		Leucrocuta					
		Stenacron					
		Stenonema		2	3	4	2
	Isonychiidae	*Isonychia*			14		
	Leptophlebiidae	*Leptophlebia*					
		Paraleptophlebia			1		
	Polymitarcidae	*Ephoron*					
	Potamanthidae	*Anthopotamus*					
	Siphlonuridae	*Parameletus*					
		Siphlonurus					
	Tricorythidae	*Leptohyphes*					
		Tricorythodes					
Megaloptera	Corydalidae	*Corydalus*	3	1			
		Nigronia			3	4	
	Sialidae	*Sialis*			3	1	
	Sisyridae	*Sisyra*					
Hemiptera	Veliidae	*Rhagovelia*					
Odonata	Coenagrionidae	*Argia*					
		Nehalennia					

Order	Family	Genus	MIDL 24.7 67b	MNDA 0.1 67b	NMHT 0.0 67b	NMID 0.7 67b	PAXT 8.4 67b
	Gomphidae	*Arigomphus*					
		Gomphus				1	
		Stylogomphus					
Plecoptera	Capniidae	*Paracapnia*					
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*					
	Nemouridae	*Amphinemura*					
	Peltoperlidae	*Peltoperla*					
	Perlidae	*Acroneuria*		3		1	
		Agnetina					
		Eccoptura					
		Neoperla		2			
		Paragnetina					
		Perlesta					
	Perlodidae	*Cultus*			1		
	Pteronarcyidae	*Pteronarcys*					
	Taeniopterygidae	*Strophopteryx*					
Trichoptera	Brachycentridae	*Brachycentrus*					
		Micrasema					
	Glossomatidae	*Glossosoma*					
	Hydropsychidae	*Ceratopsyche*			4	21	1
		Cheumatopsyche	57		32	6	3
		Hydropsyche	5	9		1	2
		Macrostemum					
		Potamyia			4		
	Leptoceridae	*Mystacides*					
	Philopotamidae	*Chimarra*	21		9		
		Dolophilodes					
	Polycentropodidae	*Neureclipsis*					
		Nyctiophylax					
		Polycentropus					
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*					
Amphipoda	Gammaridae	*Gammarus*				2	16
	Talitridae	*Hyalella*					
Isopoda	Asellidae	*Caecidotea*					
Decapoda	Cambaridae	*Cambarus*					
		Orconectes					
		Procambarus					
Gastropoda	Ancylidae	*Ferrissia*					
	Lymnaeidae	*Lymnaea*					
	Physidae	*Physa*					
		Viviparus					
	Planorbidae	*Gyraulus*					
Pelecypoda	Corbiculidae	*Corbicula*					
	Sphaeriidae	*Psidium*	2				
Hydracarina							
Gnathobdellida	Hirudinidae	*Helobdella*					
Haplotaxida	Naididae	*Nias*					
	Tubificidae						
	Lumbriculidae	*Rhynchelmis*					
Gordioida	Gordiidae	*Gordius*					
Rhynchobdellida	Glossiphoniidae	*Batracobdella*					
Tricladida	Planariidae	*Dugesia*					

Order	Family	Genus	POWL 0.1	QUIT 0.3	SWAT 39.0	SWAT 56.0	WMHT 2.2
			67b	67b	67b	67b	67b
Coleoptera	Elmidae	*Ancyronyx*					
		Dubiraphia					
		Macronychus					
		Microcylloepus					
		Optioservus		5			2
		Ordobrevia			2	2	2
		Stenelmis	2	14	2	1	7
	Gyrinidae	*Dineutis*					
	Hydrophilidae	*Berosus*					
		Hydrobius					
	Psephenidae	*Psephenus*	1			1	27
		Ectopria					
Diptera	Athericidae	*Atherix*	1				
	Chironomidae		8	1	2	12	4
	Dixidae		1				
	Empididae	*Hemerodromia*		1		21	7
	Simuliidae		3	2	1		
	Tabanidae	*Tabanus*					1
	Tipulidae	*Antocha*		1			
		Hexatoma					2
		Limonia					
		Tipula		1			
Ephemeroptera	Baetidae	*Baetis*	49		8		2
		Centroptilum					
		Pseudocloeon					
	Caenidae	*Brachycercus*					
		Caenis					
	Ephemerellidae	*Drunella*					
		Ephemerella					
		Serratella					
	Ephemeridae	*Ephemera*					
		Hexagenia					
	Heptageniidae	*Epeorus*					2
		Heptagenia					
		Leucrocuta	2				
		Stenacron	5		1		
		Stenonema			6	1	1
	Isonychiidae	*Isonychia*			8		19
	Leptophlebiidae	*Leptophlebia*					
		Paraleptophlebia					
	Polymitarcidae	*Ephoron*					
	Potamanthidae	*Anthopotamus*					
	Siphlonuridae	*Parameletus*					
		Siphlonurus					
	Tricorythidae	*Leptohyphes*					
		Tricorythodes					
Megaloptera	Corydalidae	*Corydalus*			1		
		Nigronia			2		4
	Sialidae	*Sialis*					1
	Sisyridae	*Sisyra*					
Hemiptera	Veliidae	*Rhagovelia*					1
Odonata	Coenagrionidae	*Argia*					
		Nehalennia					

Order	Family	Genus	POWL 0.1	QUIT 0.3	SWAT 39.0	SWAT 56.0	WMHT 2.2
			67b	67b	67b	67b	67b
	Gomphidae	*Arigomphus*					
		Gomphus					
		Stylogomphus					
Plecoptera	Capniidae	*Paracapnia*					
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*					
	Nemouridae	*Amphinemura*					
	Peltoperlidae	*Peltoperla*					
	Perlidae	*Acroneuria*	2		1		7
		Agnetina					1
		Eccoptura	1				
		Neoperla	2				
		Paragnetina					
		Perlesta					
	Perlodidae	*Cultus*					
	Pteronarcyidae	*Pteronarcys*				1	
	Taeniopterygidae	*Strophopteryx*					
Trichoptera	Brachycentridae	*Brachycentrus*					
		Micrasema					
	Glossomatidae	*Glossosoma*					
	Hydropsychidae	*Ceratopsyche*		4	32	1	14
		Cheumatopsyche			42		1
		Hydropsyche	57		2		
		Macrostemum		9			
		Potamyia					
	Leptoceridae	*Mystacides*					
	Philopotamidae	*Chimarra*	9		2		3
		Dolophilodes					
	Polycentropodidae	*Neureclipsis*					
		Nyctiophylax					
		Polycentropus					
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*					
Amphipoda	Gammaridae	*Gammarus*		52			
	Talitridae	*Hyalella*					
Isopoda	Asellidae	*Caecidotea*		7			
Decapoda	Cambaridae	*Cambarus*					
		Orconectes					1
		Procambarus					
Gastropoda	Ancylidae	*Ferrissia*					
	Lymnaeidae	*Lymnaea*					
	Physidae	*Physa*					1
		Viviparus					
	Planorbidae	*Gyraulus*					
Pelecypoda	Corbiculidae	*Corbicula*					
	Sphaeriidae	*Psidium*		1			5
Hydracarina							
Gnathobdellida	Hirudinidae	*Helobdella*					1
Haplotaxida	Naididae	*Nais*	1				
	Tubificidae						
	Lumbriculidae	*Rhynchelmis*					
Gordioida	Gordiidae	*Gordius*					
Rhynchobdellida	Glossiphoniidae	*Batracobdella*		2			
Tricladida	Planariidae	*Dugesia*					

Order	Family	Genus	STON 0.4	DEEP 1.2	CLRK 3.8	EPIN 0.1	EPIN 12.7
			67cd	67cd	67cd	67cd	67cd
Coleoptera	Elmidae	*Ancyronyx*					
		Dubiraphia					
		Macronychus					
		Microcylloepus					
		Optioservus	1	12	5	2	
		Ordobrevia					
		Stenelmis	4	2			3
	Gyrinidae	*Dineutus*					
	Hydrophilidae	*Berosus*					
		Hydrobius					
	Psephenidae	*Psephenus*		10	8		
		Ectopria					
Diptera	Athericidae	*Atherix*		4	5	1	2
	Chironomidae		14	2	11	13	91
	Dixidae						
	Empididae	*Hemerodromia*		1			
	Simuliidae		6				1
	Tabanidae	*Tabanus*					
	Tipulidae	*Antocha*			1		
		Hexatoma					
		Limonia	1				
		Tipula			1		
Ephemeroptera	Baetidae	*Baetis*	12	3	7	31	26
		Centroptilum			4		
		Pseudocloeon	6			1	
	Caenidae	*Brachycercus*				2	
		Caenis					
	Ephemerellidae	*Drunella*					1
		Ephemerella					
		Serratella					
	Ephemeridae	*Ephemera*					1
		Hexagenia					
	Heptageniidae	*Epeorus*					
		Heptagenia			1		
		Leucrocuta			1	6	
		Stenacron	1				
		Stenonema	[illegible]	8		6	1
	Isonychiidae	*Isonychia*	18	25	1		1
	Leptophlebiidae	*Leptophlebia*					
		Paraleptophlebia			2		
	Polymitarcidae	*Ephoron*					
	Potamanthidae	*Anthopotamus*					
	Siphlonuridae	*Parameletus*					
		Siphlonurus					
	Tricorythidae	*Leptohyphes*					
		Tricorythodes					
Megaloptera	Corydalidae	*Corydalus*					
		Nigronia	3	1	7	6	4
	Sialidae	*Sialis*	1			5	2
	Sisyridae	*Sisyra*					
Hemiptera	Veliidae	*Rhagovelia*					
Odonata	Coenagrionidae	*Argia*					
		Nehalennia					

Order	Family	Genus	STON 0.4	DEEP 1.2	CLRK 3.8	EPIN 0.1	EPIN 12.7
			67cd	67cd	67cd	67cd	67cd
	Gomphidae	*Arigomphus*					
		Gomphus	1				
		Stylogomphus					
Plecoptera	Capniidae	*Paracapnia*	4				
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*		1	3		1
	Nemouridae	*Amphinemura*					
	Peltoperlidae	*Peltoperla*					
	Perlidae	*Acroneuria*	16	2	2		1
		Agnetina			8		
		Eccoptura					
		Neoperla					
		Paragnetina		5	2		
		Perlesta					
	Perlodidae	*Cultus*					
	Pteronarcyidae	*Pteronarcys*					
	Taeniopterygidae	*Strophopteryx*					
Trichoptera	Brachycentridae	*Brachycentrus*					
		Micrasema					
	Glossomatidae	*Glossosoma*					
	Hydropsychidae	*Ceratopsyche*	13	37	5	64	
		Cheumatopsyche	12	4	11	4	15
		Hydropsyche					14
		Macrostemum					
		Potamyia			3		
	Leptoceridae	*Mystacides*					
	Philopotamidae	*Chimarra*			7		1
		Dolophilodes	1	2	4		1
	Polycentropodidae	*Neureclipsis*					
		Nyctiophylax					
		Polycentropus					4
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*			2		
Amphipoda	Gammaridae	*Gammarus*	2				
	Talitridae	*Hyalella*					
Isopoda	Asellidae	*Caecidotea*					
Decapoda	Cambaridae	*Cambarus*					
		Orconectes			1	4	
		Procambarus					
Gastropoda	Ancylidae	*Ferrissia*					
	Lymnaeidae	*Lymnaea*					
	Physidae	*Physa*					
		Viviparus					
	Planorbidae	*Gyraulus*					
Pelecypoda	Corbiculidae	*Corbicula*					
	Sphaeriidae	*Psidium*					
Hydracarina						4	
Gnathobdellida	Hirudinidae	*Helobdella*					
Haplotaxida	Naididae	*Nias*					
	Tubificidae						1
	Lumbriculidae	*Rhynchelmis*					
Gordioida	Gordiidae	*Gordius*					
Rhynchobdellida	Glossiphoniidae	*Batracobdella*					
Tricladida	Planariidae	*Dugesia*					

Order	Family	Genus	LRLS 0.5	CONO 1.3	CONO 28.8	CONO 51.8	CONO 66.0
			67cd	67L	67L	67L	67L
Coleoptera	Elmidae	*Ancyronyx*					
		Dubiraphia			1		
		Macronychus					
		Microcylloepus					
		Optioservus	1	10	5	14	13
		Ordobrevia	1		3		
		Stenelmis			52	36	6
	Gyrinidae	*Dineutis*					
	Hydrophilidae	*Berosus*					
		Hydrobius				1	
	Psephenidae	*Psephenus*		26	20		8
		Ectopria					
Diptera	Athericidae	*Atherix*					
	Chironomidae		1	2	2	28	6
	Dixidae						
	Empididae	*Hemerodromia*				4	
	Simuliidae		6				
	Tabanidae	*Tabanus*					
	Tipulidae	*Antocha*					
		Hexatoma					
		Limonia	1				
		Tipula					
Ephemeroptera	Baetidae	*Baetis*	5	40	8	13	7
		Centroptilum					
		Pseudocloeon			1		
	Caenidae	*Brachycercus*					6
		Caenis				3	
	Ephemerellidae	*Drunella*					
		Ephemerella				1	1
		Serratella					
	Ephemeridae	*Ephemera*					
		Hexagenia					
	Heptageniidae	*Epeorus*					
		Heptagenia		4		1	
		Leucrocuta		2			
		Stenacron					1
		Stenonema		14	17		7
	Isonychiidae	*Isonychia*		4	6	7	10
	Leptophlebiidae	*Leptophlebia*					
		Paraleptophlebia					
	Polymitarcidae	*Ephoron*			2	2	
	Potamanthidae	*Anthopotamus*					
	Siphlonuridae	*Parameletus*					
		Siphlonurus					
	Tricorythidae	*Leptohyphes*					
		Tricorythodes					
Megaloptera	Corydalidae	*Corydalus*	1	3		2	
		Nigronia					
	Sialidae	*Sialis*		1		1	
	Sisyridae	*Sisyra*					
Hemiptera	Veliidae	*Rhagovelia*					
Odonata	Coenagrionidae	*Argia*		6	1		
		Nehalennia					

Order	Family	Genus	LRLS 0.5	CONO 1.3	CONO 28.8	CONO 51.8	CONO 66.0
			67cd	67L	67L	67L	67L
	Gomphidae	*Arigomphus*					
		Gomphus					
		Stylogomphus					
Plecoptera	Capniidae	*Paracapnia*					
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*					
	Nemouridae	*Amphinemura*					
	Peltoperlidae	*Peltoperla*					
	Perlidae	*Acroneuria*	1		2		
		Agnetina	10			1	
		Eccoptura					
		Neoperla					
		Paragnetina		1			
		Perlesta					
	Perlodidae	*Cultus*					
	Pteronarcyidae	*Pteronarcys*				1	
	Taeniopterygidae	*Strophopteryx*					
Trichoptera	Brachycentridae	*Brachycentrus*		1			
		Micrasema					
	Glossomatidae	*Glossosoma*					
	Hydropsychidae	*Ceratopsyche*	4	7	13		24
		Cheumatopsyche	5	9	7	16	17
		Hydropsyche	1	12		24	
		Macrostemum				2	
		Potamyia					
	Leptoceridae	*Mystacides*					
	Philopotamidae	*Chimarra*				5	
		Dolophilodes				1	
	Polycentropodidae	*Neureclipsis*				1	
		Nyctiophylax					
		Polycentropus					
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*					
Amphipoda	Gammaridae	*Gammarus*		2	1		
	Talitridae	*Hyalella*					
Isopoda	Asellidae	*Caecidotea*					
Decapoda	Cambaridae	*Cambarus*					
		Orconectes			2	1	1
		Procambarus					
Gastropoda	Ancylidae	*Ferrissia*					
	Lymnaeidae	*Lymnaea*					
	Physidae	*Physa*				2	
		Viviparus					1
	Planorbidae	*Gyraulus*					
Pelecypoda	Corbiculidae	*Corbicula*					
	Sphaeriidae	*Psidium*				1	
Hydracarina						1	
Gnathobdellida	Hirudinidae	*Helobdella*					
Haplotaxida	Naididae	*Nais*					
	Tubificidae						
	Lumbriculidae	*Rhynchelmis*	4			1	
Gordioida	Gordiidae	*Gordius*					
Rhynchobdellida	Glossiphoniidae	*Batracobdella*					
Tricladida	Planariidae	*Dugesia*					

Order	Family	Genus	EMAH 0.2	MHNY 0.3	MIDL 0.7	PENN 5.0	PENN 30.0
			67L	67L	67L	67L	67L
Coleoptera	Elmidae	*Ancyronyx*		1			
		Dubiraphia				1	
		Macronychus					
		Microcylloepus					
		Optioservus	1	1	12		4
		Ordobrevia	2		2		
		Stenelmis	6	5	9	12	5
	Gyrinidae	*Dineutis*				1	
	Hydrophilidae	*Berosus*					
		Hydrobius					
	Psephenidae	*Psephenus*	3		10	8	10
		Ectopria					
Diptera	Athericidae	*Atherix*		1			8
	Chironomidae		6	15	43	16	11
	Dixidae						
	Empididae	*Hemerodromia*		14			
	Simuliidae						
	Tabanidae	*Tabanus*					
	Tipulidae	*Antocha*					
		Hexatoma					
		Limonia			1		
		Tipula					
Ephemeroptera	Baetidae	*Baetis*	13		8	16	5
		Centroptilum					1
		Pseudocloeon					2
	Caenidae	*Brachycercus*			2		1
		Caenis					
	Ephemerellidae	*Drunella*					3
		Ephemerella					
		Serratella					
	Ephemeridae	*Ephemera*	1				
		Hexagenia			2		
	Heptageniidae	*Epeorus*					1
		Heptagenia	1			2	1
		Leucrocuta				7	
		Stenacron	4				
		Stenonema	35		18	14	7
	Isonychiidae	*Isonychia*	8		7	7	32
	Leptophlebiidae	*Leptophlebia*					
		Paraleptophlebia					
	Polymitarcidae	*Ephoron*	13		16	6	39
	Potamanthidae	*Anthopotamus*				11	
	Siphlonuridae	*Parameletus*					
		Siphlonurus					
	Tricorythidae	*Leptohyphes*					
		Tricorythodes				1	
Megaloptera	Corydalidae	*Corydalus*			2	1	6
		Nigronia					
	Sialidae	*Sialis*	1			4	
	Sisyridae	*Sisyra*					
Hemiptera	Veliidae	*Rhagovelia*					
Odonata	Coenagrionidae	*Argia*					
		Nehalennia				3	

Order	Family	Genus	EMAH 0.2	MHNY 0.3	MIDL 0.7	PENN 5.0	PENN 30.0
			67L	67L	67L	67L	67L
	Gomphidae	*Arigomphus*					
		Gomphus					
		Stylogomphus					1
Plecoptera	Capniidae	*Paracapnia*					
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*					
	Nemouridae	*Amphinemura*					
	Peltoperlidae	*Peltoperla*					
	Perlidae	*Acroneuria*	1		1	2	
		Agnetina					3
		Eccoptura					
		Neoperla				2	
		Paragnetina					
		Perlesta					
	Perlodidae	*Cultus*					
	Pteronarcyidae	*Pteronarcys*					
	Taeniopterygidae	*Strophopteryx*					
Trichoptera	Brachycentridae	*Brachycentrus*					
		Micrasema				1	
	Glossomatidae	*Glossosoma*					
	Hydropsychidae	*Ceratopsyche*		57	46		15
		Cheumatopsyche	1		21	5	9
		Hydropsyche		5	5	4	3
		Macrostemum					
		Potamyia	3				
	Leptoceridae	*Mystacides*					
	Philopotamidae	*Chimarra*	1				4
		Dolophilodes					
	Polycentropodidae	*Neureclipsis*				2	
		Nyctiophylax					
		Polycentropus					
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*					
Amphipoda	Gammaridae	*Gammarus*	1				
	Talitridae	*Hyalella*	1				
Isopoda	Asellidae	*Caecidotea*					
Decapoda	Cambaridae	*Cambarus*					
		Orconectes					
		Procambarus					
Gastropoda	Ancylidae	*Ferrissia*					
	Lymnaeidae	*Lymnaea*					
	Physidae	*Physa*				2	
		Viviparus					
	Planorbidae	*Gyraulus*					
Pelecypoda	Corbiculidae	*Corbicula*					
	Sphaeriidae	*Psidium*				7	1
Hydracarina							
Gnathobdellida	Hirudinidae	*Helobdella*					
Haplotaxida	Naididae	*Nais*					
	Tubificidae						
	Lumbriculidae	*Rhynchelmis*					
Gordioida	Gordiidae	*Gordius*					
Rhynchobdellida	Glossiphoniidae	*Batracobdella*					
Tricladida	Planariidae	*Dugesia*					

Order	Family	Genus	SHRM 2.0 67L	SHRM 27.5 67L	WICO 0.3 67L	YLBR 3.4 67L	YLBR 35.7 67L
Coleoptera	Elmidae	*Ancyronyx*					
		Dubiraphia					1
		Macronychus					
		Microcylloepus					
		Optioservus	3	2		12	37
		Ordobrevia	1				
		Stenelmis	4	6		13	22
	Gyrinidae	*Dineutis*			1		
	Hydrophilidae	*Berosus*					
		Hydrobius					
	Psephenidae	*Psephenus*	13	13		8	27
		Ectopria					
Diptera	Athericidae	*Atherix*		1			
	Chironomidae		3	7	16	1	2
	Dixidae						
	Empididae	*Hemerodromia*				2	
	Simuliidae				1	2	
	Tabanidae	*Tabanus*		2			
	Tipulidae	*Antocha*			1	1	3
		Hexatoma					
		Limonia			1		
		Tipula					
Ephemeroptera	Baetidae	*Baetis*	6	4	18	10	18
		Centroptilum					
		Pseudocloeon	3		1		
	Caenidae	*Brachycercus*				3	4
		Caenis					
	Ephemerellidae	*Drunella*					
		Ephemerella					
		Serratella					
	Ephemeridae	*Ephemera*					
		Hexagenia					1
	Heptageniidae	*Epeorus*					
		Heptagenia	2				1
		Leucrocuta		2		1	
		Stenacron					
		Stenonema	3	1	6	7	6
	Isonychiidae	*Isonychia*	36	48	42		
	Leptophlebiidae	*Leptophlebia*					
		Paraleptophlebia					
	Polymitarcidae	*Ephoron*	1	2			4
	Potamanthidae	*Anthopotamus*					
	Siphlonuridae	*Parameletus*					
		Siphlonurus					2
	Tricorythidae	*Leptohyphes*					
		Tricorythodes					
Megaloptera	Corydalidae	*Corydalus*		3			
		Nigronia					
	Sialidae	*Sialis*	1				
	Sisyridae	*Sisyra*	1				
Hemiptera	Veliidae	*Rhagovelia*					
Odonata	Coenagrionidae	*Argia*					
		Nehalennia					

Order	Family	Genus	SHRM 2.0 67L	SHRM 27.5 67L	WICO 0.3 67L	YLBR 3.4 67L	YLBR 35.7 67L
	Gomphidae	*Arigomphus*					
		Gomphus					
		Stylogomphus					
Plecoptera	Capniidae	*Paracapnia*					
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*					
	Nemouridae	*Amphinemura*					
	Peltoperlidae	*Peltoperla*					
	Perlidae	*Acroneuria*	5	1	1		
		Agnetina					3
		Eccoptura					
		Neoperla					
		Paragnetina				2	
		Perlesta					
	Perlodidae	*Cultus*					
	Pteronarcyidae	*Pteronarcys*				1	
	Taeniopterygidae	*Strophopteryx*					
Trichoptera	Brachycentridae	*Brachycentrus*				5	1
		Micrasema					
	Glossomatidae	*Glossosoma*					
	Hydropsychidae	*Ceratopsyche*	36	5	26	11	8
		Cheumatopsyche	13	4	6		5
		Hydropsyche	7	1	4		
		Macrostemum		2			
		Potamyia	3				
	Leptoceridae	*Mystacides*					
	Philopotamidae	*Chimarra*		18	3		3
		Dolophilodes	1				
	Polycentropodidae	*Neureclipsis*					
		Nyctiophylax					
		Polycentropus					
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*					1
Amphipoda	Gammaridae	*Gammarus*				39	11
	Talitridae	*Hyalella*					
Isopoda	Asellidae	*Caecidotea*					2
Decapoda	Cambaridae	*Cambarus*					
		Orconectes		2			
		Procambarus					
Gastropoda	Ancylidae	*Ferrissia*					
	Lymnaeidae	*Lymnaea*					
	Physidae	*Physa*					2
		Viviparus					
	Planorbidae	*Gyraulus*					
Pelecypoda	Corbiculidae	*Corbicula*					
	Sphaeriidae	*Psidium*	1	19			1
Hydracarina							
Gnathobdellida	Hirudinidae	*Helobdella*					
Haplotaxida	Naididae	*Nias*					
	Tubificidae						
	Lumbriculidae	*Rhynchelmis*				2	
Gordioida	Gordiidae	*Gordius*					
Rhynchobdellida	Glossiphoniidae	*Batracobdella*					
Tricladida	Planariidae	*Dugesia*					

Order	Family	Genus	SUSQ 44.5	SUSQ 57.0	SUSQ 77.0	SUSQ 94.0	SUSQ 106.0
Coleoptera	Elmidae	*Ancyronyx*					
		Dubiraphia					1
		Macronychus					1
		Microcylloepus					
		Optioservus	1		4	2	1
		Ordobrevia				2	
		Stenelmis	1	15	8	38	4
	Gyrinidae	*Dineutis*	1				
	Hydrophilidae	*Berosus*					
		Hydrobius					
	Psephenidae	*Psephenus*				2	
		Ectopria					
Diptera	Athericidae	*Atherix*					
	Chironomidae		2	2	1	2	1
	Dixidae						
	Empididae	*Hemerodromia*					
	Simuliidae						
	Tabanidae	*Tabanus*					
	Tipulidae	*Antocha*					
		Hexatoma	1				
		Limonia					
		Tipula			1		1
Ephemeroptera	Baetidae	*Baetis*	47		11	6	9
		Centroptilum	6				
		Pseudocloeon					
	Caenidae	*Brachycercus*			22		
		Caenis					
	Ephemerellidae	*Drunella*					
		Ephemerella					
		Serratella					
	Ephemeridae	*Ephemera*					
		Hexagenia					
	Heptageniidae	*Epeorus*					
		Heptagenia			2	1	
		Leucrocuta					2
		Stenacron	1	12	1	3	2
		Stenonema	12	5	11	8	10
	Isonychiidae	*Isonychia*	1			1	7
	Leptophlebiidae	*Leptophlebia*				1	
		Paraleptophlebia					
	Polymitarcidae	*Ephoron*				1	
	Potamanthidae	*Anthopotamus*				2	
	Siphlonuridae	*Parameletus*					
		Siphlonurus					
	Tricorythidae	*Leptohyphes*				4	
		Tricorythodes		1	1	2	
Megaloptera	Corydalidae	*Corydalus*		1		1	20
		Nigronia				2	
	Sialidae	*Sialis*	1	2	4	1	
	Sisyridae	*Sisyra*					
Hemiptera	Veliidae	*Rhagovelia*					
Odonata	Coenagrionidae	*Argia*	2	1			1
		Nehalennia					

Order	Family	Genus	SUSQ 44.5	SUSQ 57.0	SUSQ 77.0	SUSQ 94.0	SUSQ 106.0
	Gomphidae	*Arigomphus*					
		Gomphus					
		Stylogomphus					
Plecoptera	Capniidae	*Paracapnia*					
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*					
	Nemouridae	*Amphinemura*					
	Peltoperlidae	*Peltoperla*					
	Perlidae	*Acroneuria*			1		
		Agnetina					2
		Eccoptura					
		Neoperla					
		Paragnetina					1
		Perlesta					
	Perlodidae	*Cultus*					
	Pteronarcyidae	*Pteronarcys*					
	Taeniopterygidae	*Strophopteryx*					
Trichoptera	Brachycentridae	*Brachycentrus*					
		Micrasema					
	Glossomatidae	*Glossosoma*					
	Hydropsychidae	*Ceratopsyche*			7	1	
		Cheumatopsyche	12	7			14
		Hydropsyche	3	5	15		
		Macrostemum					
		Potamyia			4	3	
	Leptoceridae	*Mystacides*					
	Philopotamidae	*Chimarra*	9	4		3	18
		Dolophilodes					
	Polycentropodidae	*Neureclipsis*					
		Nyctiophylax					
		Polycentropus					
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*					
Amphipoda	Gammaridae	*Gammarus*		41	7	12	
	Talitridae	*Hyalella*					
Isopoda	Asellidae	*Caecidotea*				11	
Decapoda	Cambaridae	*Cambarus*		2			
		Orconectes					
		Procambarus					
Gastropoda	Ancylidae	*Ferrissia*					
	Lymnaeidae	*Lymnaea*					
	Physidae	*Physa*					
		Viviparus					
	Planorbidae	*Gyraulus*					
Pelecypoda	Corbiculidae	*Corbicula*		2			
	Sphaeriidae	*Psidium*	2	3		1	6
Hydracarina							
Gnathobdellida	Hirudinidae	*Helobdella*		2			
Haplotaxida	Naididae	*Nais*					
	Tubificidae						
	Lumbriculidae	*Rhynchelmis*	1				
Gordioida	Gordiidae	*Gordius*					
Rhynchobdellida	Glossiphoniidae	*Batracobdella*				1	
Tricladida	Planariidae	*Dugesia*					

Order	Family	Genus	SUSQ 122.0
Coleoptera	Elmidae	*Ancyronyx*	
		Dubiraphia	
		Macronychius	
		Microcylloepus	
		Optioservus	
		Ordobrevia	
		Stenelmis	2
	Gyrinidae	*Dineutis*	
	Hydrophilidae	*Berosus*	
		Hydrobius	
	Psephenidae	*Psephenus*	
		Ectopria	
Diptera	Athericidae	*Atherix*	
	Chironomidae		13
	Dixidae		
	Empididae	*Hemerodromia*	2
	Simuliidae		
	Tabanidae	*Tabanus*	
	Tipulidae	*Antocha*	
		Hexatoma	
		Limonia	
		Tipula	
Ephemeroptera	Baetidae	*Baetis*	6
		Centroptilum	
		Pseudocloeon	
	Caenidae	*Brachycercus*	6
		Caenis	
	Ephemerellidae	*Drunella*	
		Ephemerella	
		Serratella	
	Ephemeridae	*Ephemera*	
		Hexagenia	
	Heptageniidae	*Epeorus*	
		Heptagenia	
		Leucrocuta	4
		Stenacron	
		Stenonema	3
	Isonychiidae	*Isonychia*	1
	Leptophlebiidae	*Leptophlebia*	
		Paraleptophlebia	
	Polymitarcidae	*Ephoron*	
	Potamanthidae	*Anthopotamus*	
	Siphlonuridae	*Parameletus*	
		Siphlonurus	
	Tricorythidae	*Leptohyphes*	
		Tricorythodes	
Megaloptera	Corydalidae	*Corydalus*	7
		Nigronia	
	Sialidae	*Sialis*	1
	Sisyridae	*Sisyra*	
Hemiptera	Veliidae	*Rhagovelia*	
Odonata	Coenagrionidae	*Argia*	3
		Nehalennia	

Order	Family	Genus	SUSQ 122.0
	Gomphidae	*Arigomphus*	
		Gomphus	
		Stylogomphus	
Plecoptera	Capniidae	*Paracapnia*	
	Chloroperlidae	*Alloperla*	
	Leuctridae	*Leuctra*	
	Nemouridae	*Amphinemura*	
	Peltoperlidae	*Peltoperla*	
	Perlidae	*Acroneuria*	
		Agnetina	
		Eccoptura	
		Neoperla	
		Paragnetina	
		Perlesta	
	Perlodidae	*Cultus*	
	Pteronarcyidae	*Pteronarcys*	
	Taeniopterygidae	*Strophopteryx*	
Trichoptera	Brachycentridae	*Brachycentrus*	
		Micrasema	
	Glossomatidae	*Glossosoma*	
	Hydropsychidae	*Ceratopsyche*	
		Cheumatopsyche	8
		Hydropsyche	
		Macrostemum	
		Potamyia	
	Leptoceridae	*Mystacides*	
	Philopotamidae	*Chimarra*	47
		Dolophilodes	
	Polycentropodidae	*Neureclipsis*	
		Nyctiophylax	
		Polycentropus	
	Psychomyiidae	*Lype*	
	Rhyacophilidae	*Rhyacophila*	
Amphipoda	Gammaridae	*Gammarus*	2
	Talitridae	*Hyalella*	
Isopoda	Asellidae	*Caecidotea*	
Decapoda	Cambaridae	*Cambarus*	
		Orconectes	
		Procambarus	
Gastropoda	Ancylidae	*Ferrissia*	
	Lymnaeidae	*Lymnaea*	
	Physidae	*Physa*	
		Viviparus	
	Planorbidae	*Gyraulus*	
Pelecypoda	Corbiculidae	*Corbicula*	
	Sphaeriidae	*Psidium*	9
Hydracarina			
Gnathobdellida	Hirudinidae	*Helobdella*	
Haplotaxida	Naididae	*Nias*	
	Tubificidae		
	Lumbriculidae	*Rhynchelmis*	
Gordioida	Gordiidae	*Gordius*	
Rhynchobdellida	Glossiphoniidae	*Batracobdella*	
Tricladida	Planariidae	*Dugesia*	

Appendix C

Drainage Area and Subecoregion Designation

Sample Site	Reference Cateory	Subecoregion Designation	Drainage Area (square miles)
ARMS 0.1	67b	67b	32.3
BEAV 0.6	67a	67a	27.2
BERM 1.2	64L	64a	110.0
BERM 11.0	64ac	64a	31.8
CCLC 0.4	64L	64d	140.0
CCLC 12.2	64d	64d	72.4
CHCK 3.0	64L	64d	126.0
CLRK 3.8	67cd	67c	44.9
CNTG 0.9	64L	64d	477.0
CNTG 22.6	64L	64d	324.0
CNTG 32.7	64L	64d	182.0
CNTG 43.9	64L	64d	117.0
CNWG 1.8	64ac	64c	34.4
CODO 0.6	64L	64a	278.0
CODO 22.4	64L	64d	133.3
CODO 33.0	64L	64d	106.0
CODO 34.1	64ac	64c	82.4
CONO 1.3	67L	67b	506.0
CONO 28.8	67L	67b	433.0
CONO 51.8	67L	67b	342.6
CONO 66.0	67L	67b	193.8
DEEP 1.2	67cd	67d	31.8
DEER 1.2	64L	64c	169.0
DEER 30.1	64ac	64c	25.5
EBOC 5.3	64ac	64c	90.6
ECON 0.0	64ac	64a	52.5
ELKN 0.1	67a	67a	56.8
EMAH 0.2	67L	67b	164.0
EMAH 17.1	67b	67b	71.9
EPIN 0.1	67cd	67d	76.8
EPIN 12.7	67cd	67d	45.0
HAMM 0.2	64d	64d	35.2
KRTZ 1.5	64d	64d	34.2
LCHK 0.4	64d	64d	44.5
LCNT 1.7	64d	64d	65.5
LCON 1.5	64ac	64a	65.4
LRLN 0.8	67b	67b	20.1
LRLS 0.5	67cd	67c	26.8
LSHM 0.8	67b	67b	29.1
LSWT 0.6	67b	67b	99.2
LTRT 0.1	67a	67a	21.7
MDDY 3.3	64L	64c	138.0
MHNY 0.3	67L	67b	157.0
MIDD 0.2	64d	64d	32.4
MIDL 0.7	67L	67b	175.0
MIDL 24.7	67b	67b	95.9

Sample Site	Reference Category	Subecoregion Designation	Drainage Area (square miles)
MILL 0.3	64d	64d	56.4
MISP 0.5	67a	67a	45.8
MNDA 0.1	67b	67b	32.2
MNTN 3.0	66	66a	47.6
MUDD 0.2	64d	64d	51.8
NBMY 0.0	64ac	64c	43.8
NMHT 0.0	67b	67b	37.1
NMID 0.7	67b	67b	36.8
OCTO 1.0	64L	64c	176.0
PAXT 0.5	67b	67b	27.4
PAXT 8.4	67b	67b	11.2
PENN 30.0	67L	67b	240.0
PENN 5.0	67L	67b	306.0
PENN 50.6	67a	67a	56.0
POWL 0.1	67b	67b	39.7
PQEA 15.2	64L	64d	116.7
PQEA 3.3	64L	64d	154.0
QUIT 0.3	67b	67b	77.3
SBCC 1.2	64ac	64a	73.5
SBCD 0.4	64L	64c	117.0
SBCD 3.6	64ac	64c	72.5
SBEV 2.5	64d	64d	21.4
SBMY 0.0	64ac	64c	28.1
SHAM 2.7	67L	67b	137.0
SHRM 2.0	67L	67b	244.0
SHRM 27.5	67L	67a	150.1
SPRG 0.0	67a	67a	24.0
STON 0.4	67cd	67c	35.6
SWAT 2.3	64L	64a	571.0
SWAT 21.7	67L	67b	286.0
SWAT 39.0	67b	67b	72.1
SWAT 56.0	67b	67b	68.9
TRDL 0.0	67a	67a	19.6
WBOC 4.3	64ac	64c	48.1
WCON 2.9	64L	64a	510.0
WCON 20.4	64L	64a	448.0
WCON 35.5	64L	64a	296.4
WCON 56.3	64L	64a	184.2
WCON 66.5	64L	64a	129.5
WICO 0.3	67L	67d	116.0
WMHT 2.2	67b	67b	46.9
WPIN 0.8	67a	67a	36.4
YLBR 3.4	67L	67a	216.0
YLBR 35.7	67L	67a	122.8

Sources: Pa. DER (1989) and Pa. DEP (unpublished)

Appendix D

Raw Water Quality Data From Sample Sites in the Lower Susquehanna Subbasin

Parameter Symbol	Parameter Name	Units	BERM 11.0	CNWG 1.8	CODO 34.1	DEER 30.1	EBOC 5.3	ECON 0.0	LCON 1.5	NBMY 0.0	SBCC 1.2
RC	Reference Category		64ac	64ac	64ac	64ac	64ac	64ac	64ac	64ac	64ac
Date	Date	yymmdd	960723	960725	960725	960814	960725	960723	960724	960815	960723
Time	Time	hhmm	1415	1430	1430	1350	1000	1300	1330	1335	1050
Temp	Water Temperature	°C	19.1	23.5	22.2	17.7	20.3	19.5	21.9	18.7	18.5
pH	pH (field)	S.U.	7.85	7.95	7.6	7.1	7.55	7.7	7.6	7.05	7.75
DO	Dissolved Oxygen	mg/L	8.68	7.92	8.89	9.02	8.03	8.03	8.82	9.04	7.78
Cond	Conductivity (field)	µ ohms/cm	202	217	157	141	217	277	324	127	376
Alk	Alkalinity (field)	mg/L	70	36	46	26	56	84	104	18	126
Acid	Acidity	mg/L	4	2	4	5	2	5	6	4	6
Lab cond	Specific Conductivity	µ ohms/cm	206	218	160	143	280	280	329	131	375
Lab pH	pH (lab)	mg/L	6.7	7.2	6.5	6.6	7.2	7	6.9	6.8	7.1
Lab Alk	Alkalinity (as CaCO3)	mg/L	62	34	38	24	52	72	104	22	118
D Res	Dissolved Residuals	mg/L	178	190	46	110	214	302	290	98	296
T Res	Total Residuals	mg/L	22	2	62	10	2	22	2	2	12
TN	Total Nitrogen	mg/L	2.29	9.5	4.22	3.11	7.92	4.75	3.52	4.93	5.1
DN	Dissolved Nitrogen	mg/L	2.29	8.97	4.05	2.99	7.92	4.75	3.52	4.57	4.93
DNH3	Dissolved Ammonia	mg/L	0.02	0.02	0.02	0.02	0.02	0.12	0.02	0.02	0.02
TNH3	Total Ammonia	mg/L	0.02	0.02	0.02	0.05	0.02	0.12	0.02	0.02	0.02
DNO2	Dissolved Nitrite	mg/L	0.006	0.018	0.004	0.006	0.022	0.01	0.006	0.004	0.012
TNO2	Total Nitrite	mg/L	0.008	0.02	0.006	0.006	0.024	0.012	0.008	0.004	0.016
DNO3	Dissolved Nitrate	mg/L	2.06	8.3	3.83	2.41	7.9	4.61	3.16	4.09	4.74
TNO3	Total Nitrate	mg/L	2.06	8.3	3.83	2.41	7.9	4.61	3.16	4.09	4.86
TP	Total Phosphorus	mg/L	0.04	0.04	0.03	0.06	0.05	0.12	0.09	0.02	0.09
DP	Dissolved Phosphorus	mg/L	0.029	0.026	0.011	0.013	0.043	0.061	0.068	0.009	0.066
TOC	Total Organic Carbon	mg/L	2.9	2.1	2.1	2.4	2.1	3.3	3	1.4	2.6
Hard	Total Hardness (CaCO3)	mg/L	70	74	54	39	97	100	120	32	131
Ca	Total Calcium	mg/L	20.9	15.5	16.9	13	29.4	30.5	40.2	10.1	49.2
Mg	Magnesium	mg/L	7.15	9.76	5.18	4.46	9.5	9.31	9.56	4.56	11.3
Na	Sodium	mg/L	7.2	6.35	5.42	8.25	8.55	10.3	11.5	4.31	11.8
K	Potassium	mg/L	2.78	2.56	2	2.66	3.69	2.65	2.97	1.59	4.24
Cl	Chloride	mg/L	9	16	11	16	17	17	18	10	21
SO4	Total Sulfate	mg/L	14.9	11.8	6.9	6.3	22.8	19.9	23.9	7	24.5
Fl	Fluoride	mg/L	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cu	Copper	µg/L	4	4	4	4	4	4	4	4	4

Parameter Symbol	Parameter Name	Units	BERM 11.0	CNWG 1.8	CODO 34.1	DEER 30.1	EBOC 5.3	ECON 0.0	LCON 1.5	NBMY 0.0	SBCC 1.2
TFe	Total Iron	µg/L	171	221	268	833	151	1,390	451	225	754
DFe	Dissolved Iron	µg/L	75	20	40	127	19	16	20	19	29
Pb	Lead	µg/L	1	1	1	1	1	1	1	1	1.6
TMn	Total Manganese	µg/L	11	15	43	86	29	79	32	20	39
DMn	Dissolved Manganese	µg/L	10	10	43	52	26	14	18	12	10
Ni	Nickel	µg/L	4	4	4	4	4	4	6.7	4	8.3
Zn	Zinc	µg/L	5	5	5	5	5	5	5	6	5.6
TAl	Total Aluminum	µg/L	73.8	126	85.9	171	74.4	537	278	81.8	295
DAl	Dissolved Aluminum	µg/L	11.5	19.5	21.7	22.7	10	12.5	12.5	10.1	14.5

Parameter Symbol	Parameter Name	Units	SBCD 3.6	SBMY 0.0	WBOC 4.3	CCLC 12.2	HAMM 0.2	KRTZ 1.5	LCHK 0.4	LCNT 1.7	MIDD 0.2
RC	Reference Category		64ac	64ac	64ac	64d	64d	64d	64d	64d	64d
Date	Date	yymmdd	960725	960815	960725	960717	960717	960805	960723	960808	960717
Time	Time	hhmm	1145	1130	1125	1415	1225	1455	930	1135	1300
Temp	Water Temperature	°C	20.7	18.3	20.2	23.8	23.6	20.6	17	21.5	21
pH	pH (field)	S.U.	7.45	7.05	7.8	8	7.8	8.1	8.05	8.15	7.59
DO	Dissolved Oxygen	mg/L	8.61	8.65	7.98	9.07	7.66	9.89	8.4	8.35	8.13
Cond	Conductivity (field)	µ ohms/cm	188	119	242	629	363	325	447	588	377
Alk	Alkalinity (field)	mg/L	44	16	42	134	124	112	126	202	136
Acid	Acidity	mg/L	4	3	2	2	4	2	2	2	12
Lab cond	Specific Conductivity	µ ohms/cm	187	122	243	638	370	333	453	612	379
Lab pH	pH (lab)	mg/L	6.4	6.6	7.1	7.3	7.9	8.1	7.4	8.1	7.1
Lab Alk	Alkalinity (as CaCO3)	mg/L	44	16.2	38	130	120	106	114	192	126
D Res	Dissolved Residuals	mg/L	148	154	170	452	274	246	388	660	306
T Res	Total Residuals	mg/L	2	2	2	2	2	2	8	3	2
TN	Total Nitrogen	mg/L	4.93	5.81	8.97	7.74	6.51	5.1	12.3	10.7	7.57
DN	Dissolved Nitrogen	mg/L	4.75	5.45	8.97	7.57	6.33	4.93	12.1	10.4	7.39
DNH3	Dissolved Ammonia	mg/L	0.04	0.02	0.05	0.06	0.02	0.02	0.08	0.02	0.02
TNH3	Total Ammonia	mg/L	0.13	0.02	0.05	0.06	0.05	0.02	0.08	0.02	0.02
DNO2	Dissolved Nitrite	mg/L	0.006	0.004	0.004	0.028	0.044	0.022	0.012	0.01	0.03
TNO2	Total Nitrite	mg/L	0.008	0.004	0.006	0.03	0.044	0.022	0.012	0.012	0.03
DNO3	Dissolved Nitrate	mg/L	4.74	4.88	8.58	6.83	5.64	4.6	12	9.49	6.7
TNO3	Total Nitrate	mg/L	4.74	4.88	8.58	6.83	5.77	4.6	12	9.49	6.7
TP	Total Phosphorus	mg/L	0.05	0.02	0.08	0.22	0.07	0.02	0.06	0.03	0.07
DP	Dissolved Phosphorus	mg/L	0.034	0.007	0.061	0.186	0.021	0.008	0.039	0.027	0.02
TOC	Total Organic Carbon	mg/L	2	1.2	1.8	3.9	3.2	1.8	1.9	2.1	3.1
Hard	Total Hardness (CaCO3)	mg/L	65	30	99	169	143	129	180	247	149
Ca	Total Calcium	mg/L	19.6	8.78	24.4	62.6	53.1	45.8	61	76.8	60.4
Mg	Magnesium	mg/L	6.19	4.5	8.53	12.9	12.1	9.39	11.1	20.3	10.6
Na	Sodium	mg/L	7.24	3.85	7.18	56	7.57	8.25	12	14.5	7.95
K	Potassium	mg/L	2.11	1.61	3.68	5.28	3.3	2.98	3.22	3.15	2.6
Cl	Chloride	mg/L	14	9	16	71	14	16	22	32	14
SO4	Total Sulfate	mg/L	8.3	5.1	15.4	53.9	20.6	17.5	27.3	40	19.3
Fl	Fluoride	mg/L	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cu	Copper	µg/L	4	4	4.8	4.9	8.5	4	4	4	4

Parameter Symbol	Parameter Name	Units	SBCD 3.6	SBMY 0.0	WBOC 4.3	CCLC 12.2	HAMM 0.2	KRTZ 1.5	LCHK 0.4	LCNT 1.7	MIDD 0.2
TFe	Total Iron	µg/L	574	272	140	384	635	181	281	152	763
DFe	Dissolved Iron	µg/L	51	77	22	24	24	18	10	123	25
Pb	Lead	µg/L	1	1	1	2	2.1	1	1	1	2.3
TMn	Total Manganese	µg/L	63	15	26	64	66	18	30	14	110
DMn	Dissolved Manganese	µg/L	31	15	20	45	15	12	13	12	61
Ni	Nickel	µg/L	4	4	4	4	4	4	7	4	4
Zn	Zinc	µg/L	5	5	5	12	30.1	5	5	5	9.9
TAl	Total Aluminum	µg/L	112	101	75.3	131	581	81.5	171	80.7	231
DAl	Dissolved Aluminum	µg/L	11.3	19.3	12	13.5	121	15.2	10	28.4	24

Parameter Symbol	Parameter Name	Units	MILL 0.3	MUDD 0.2	SBEV 2.5	BERM 1.2	CCLC 0.4	CHCK 3.0	CNTG 0.9	CNTG 22.6	CNTG 32.7
RC	Reference Category		64d	64d	64d	64L	64L	64L	64L	64L	64L
Date	Date	yymmdd	960808	960717	960724	960723	960717	960723	960808	960808	960717
Time	Time	hhmm	1010	1550	1350	1530	930	1045	1245	850	1040
Temp	Water Temperature	°C	22.6	25	23.3	21.1	21.7	17.9	24.8	24	22.5
pH	pH (field)	S.U.	8.15	7.69	8.31	8.3	7.7	7.9	8.3	8	7.85
DO	Dissolved Oxygen	mg/L	7.86	8.11	8.61	9.29	7.38	7.93	7.9	7.55	7.32
Cond	Conductivity (field)	µ ohms/cm	689	299	319	231	462	454	612	554	456
Alk	Alkalinity (field)	mg/L	230	72	92	80	138	140	196	180	156
Acid	Acidity	mg/L	2	5	0	0	4	8	0	2	8
Lab cond	Specific Conductivity	µ ohms/cm	714	302	324	233	475	462	636	575	460
Lab pH	pH (lab)	mg/L	8.1	6.9	8.3	8.2	7.3	7.5	8.1	7.8	7.9
Lab Alk	Alkalinity (as CaCO3)	mg/L	226	70	90	72	128	132	182	170	142
D Res	Dissolved Residuals	mg/L	614	220	222	200	326	214	508	448	352
T Res	Total Residuals	mg/L	4	2	2	10	6	10	2	8	2
TN	Total Nitrogen	mg/L	11.3	3.87	6.33	2.67	7.04	10.4	8.62	9.68	7.21
DN	Dissolved Nitrogen	mg/L	10.7	3.87	6.33	2.61	6.86	10.4	8.62	8.62	7.21
DNH3	Dissolved Ammonia	mg/L	0.02	0.03	0.05	0.02	0.03	0.08	0.02	0.02	0.02
TNH3	Total Ammonia	mg/L	0.03	0.03	0.05	0.02	0.04	0.08	0.02	0.02	0.02
DNO2	Dissolved Nitrite	mg/L	0.012	0.02	0.018	0.006	0.026	0.02	0.008	0.012	0.028
TNO2	Total Nitrite	mg/L	0.012	0.022	0.018	0.008	0.028	0.022	0.01	0.012	0.028
DNO3	Dissolved Nitrate	mg/L	8.57	3.28	6.05	2.45	6.57	9.75	7.12	7.51	6.83
TNO3	Total Nitrate	mg/L	8.97	3.28	6.05	2.5	6.57	9.75	7.38	7.91	6.83
TP	Total Phosphorus	mg/L	0.14	0.1	0.04	0.05	0.12	0.1	0.11	0.1	0.11
DP	Dissolved Phosphorus	mg/L	0.127	0.073	0.036	0.039	0.082	0.059	0.115	0.082	0.081
TOC	Total Organic Carbon	mg/L	2.6	3.8	1.8	3.5	3.6	2.3	3.1	3	3.5
Hard	Total Hardness (CaCO3)	mg/L	256	83	124	84	167	186	201	208	176
Ca	Total Calcium	mg/L	68.7	32	44.6	26.3	52.5	59.6	74.9	59.8	59.3
Mg	Magnesium	mg/L	31.9	8.63	7.83	8.49	12.9	17.7	22.8	19.9	17.2
Na	Sodium	mg/L	25.3	16.1	9.47	8.13	20.7	10.5	30.5	19.7	12.5
K	Potassium	mg/L	5.41	2.88	3.67	3.19	3.8	3.57	4.99	4.18	4.22
Cl	Chloride	mg/L	48	25	19	10	35	21	48	38	22
SO4	Total Sulfate	mg/L	43.6	24.6	19.9	19.1	32.4	25.4	42.3	37.9	35.2
Fl	Fluoride	mg/L	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cu	Copper	µg/L	4	4	4	4	4	4	4	4	4.3

Parameter Symbol	Parameter Name	Units	MILL 0.3	MUDD 0.2	SBEV 2.5	BERM 1.2	CCLC 0.4	CHCK 3.0	CNTG 0.9	CNTG 22.6	CNTG 32.7
TFe	Total Iron	µg/L	180	362	1,490	370	632	781	459	527	353
DFe	Dissolved Iron	µg/L	13	40	26	44	18	10	12	16	47
Pb	Lead	µg/L	1	1	1	1	1	1.9	1.1	1	1.4
TMn	Total Manganese	µg/L	15	93	24	23	57	66	54	51	63
DMn	Dissolved Manganese	µg/L	12	58	24	10	22	32	20	13	35
Ni	Nickel	µg/L	4	4	4	4	4	6.7	4	4	4
Zn	Zinc	µg/L	6.2	5	5	5	5	5	5.7	8.6	6.9
TAl	Total Aluminum	µg/L	106	127	67.4	156	239	188	116	157	158
DAl	Dissolved Aluminum	µg/L	12.4	14.1	23.6	16.1	19.3	10	21.3	10	22.7

Parameter Symbol	Parameter Name	Units	CNTG 43.9	CODO 0.6	CODO 22.4	CODO 33.0	DEER 1.2	MDDY 3.3	OCTO 1.0	PQEA 15.2	PQEA 3.3
RC	Reference Category		64L	64L	64L	64L	64L	64L	64L	64L	64L
Date	Date	yymmdd	960717	960724	960725	960725	960814	960815	960725	960724	960724
Time	Time	hhmm	1700	1505	1245	1330	1155	940	1315	1245	1140
Temp	Water Temperature	°C	25	22.1	23	14.9	19.3	18.7	25.1	20.9	20.6
pH	pH (field)	S.U.	8.05	7.95	7.55	7.15	7.15	7	8	8.3	8.35
DO	Dissolved Oxygen	mg/L	8.37	9.02	8.07	10.95	8.58	8.37	7.84	7.44	8
Cond	Conductivity (field)	µ ohms/cm	484	425	238	143	118	120	219	508	452
Alk	Alkalinity (field)	mg/L	164	104	64	38	37	22	44	188	156
Acid	Acidity	mg/L	2	4	4	4	4	4	8	0	0
Lab cond	Specific Conductivity	µ ohms/cm	471	433	237	144	122	123	218	514	456
Lab pH	pH (lab)	mg/L	7.6	7.1	6.6	6.3	6.7	6.6	7.9	8	8
Lab Alk	Alkalinity (as CaCO3)	mg/L	158	104	64	36	26	20	46	178	150
D Res	Dissolved Residuals	mg/L	404	256	194	130	140	112	158	422	352
T Res	Total Residuals	mg/L	2	2	2	2	4	2	2	2	30
TN	Total Nitrogen	mg/L	7.04	4.75	3.52	2.17	2.49	4.75	5.98	9.33	8.97
DN	Dissolved Nitrogen	mg/L	6.33	4.75	3.34	2.14	2.17	4.4	5.63	7.74	8.62
DNH3	Dissolved Ammonia	mg/L	0.03	0.02	0.03	0.05	0.07	0.02	0.02	0.03	0.02
TNH3	Total Ammonia	mg/L	0.06	0.02	0.03	0.06	0.07	0.02	0.02	0.03	0.04
DNO2	Dissolved Nitrite	mg/L	0.046	0.018	0.016	0.008	0.01	0.004	0.018	0.034	0.016
TNO2	Total Nitrite	mg/L	0.05	0.018	0.02	0.01	0.014	0.004	0.018	0.038	0.018
DNO3	Dissolved Nitrate	mg/L	5.89	4.2	3.02	1.9	1.62	3.96	5.39	6.31	8.43
TNO3	Total Nitrate	mg/L	6.29	4.2	3.02	1.9	1.66	3.96	5.39	9.07	8.43
TP	Total Phosphorus	mg/L	0.14	0.05	0.09	0.02	0.15	0.04	0.06	0.15	0.12
DP	Dissolved Phosphorus	mg/L	0.068	0.03	0.033	0.007	0.03	0.013	0.048	0.096	0.097
TOC	Total Organic Carbon	mg/L	3	4.2	2.9	2.3	4.7	1.4	3.3	1.5	1.7
Hard	Total Hardness (CaCO3)	mg/L	190	110	72	47	36	30	75	186	189
Ca	Total Calcium	mg/L	59.3	41.2	25.7	13.9	10.7	10.6	18.5	63.5	57.7
Mg	Magnesium	mg/L	26	8.71	6.86	4.82	4.32	4.77	9.71	28.2	18.5
Na	Sodium	mg/L	11.7	34.7	12.6	5.8	5.6	4.9	6.6	8.42	8.22
K	Potassium	mg/L	4.7	8.45	4.76	2.46	3.13	1.7	4.14	3.76	3.83
Cl	Chloride	mg/L	24	33	19	11	10	9	14	19	19
SO4	Total Sulfate	mg/L	36	45.3	13.5	8.9	8.7	5.8	15.6	30.2	27.9
Fl	Fluoride	mg/L	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cu	Copper	µg/L	4	4.3	4	4	4	4	4	4	4

Parameter Symbol	Parameter Name	Units	CNTG 43.9	CODO 0.6	CODO 22.4	CODO 33.0	DEER 1.2	MDDY 3.3	OCTO 1.0	PQEA 15.2	PQEA 3.3
TFe	Total Iron	µg/L	1,100	589	686	177	1,930	329	158	800	1,030
DFe	Dissolved Iron	µg/L	13	29	63	18	155	100	21	15	13
Pb	Lead	µg/L	1.7	2.7	1	1	1.2	1	1	1	1.1
TMn	Total Manganese	µg/L	101	64	132	264	73	27	29	75	52
DMn	Dissolved Manganese	µg/L	58	32	87	232	11	12	28	30	30
Ni	Nickel	µg/L	4	6.4	4	4	4	4	4	4	4
Zn	Zinc	µg/L	6.7	10.2	5.8	5	8.2	5	5	5	5
TAl	Total Aluminum	µg/L	515	89.5	142	46.2	673	121	58.3	250	242
DAl	Dissolved Aluminum	µg/L	27.8	18.1	13.8	10	54.9	12.4	14.5	16.1	14.9

Parameter Symbol	Parameter Name	Units	SBCD 0.4	SWAT 2.3	WCON 2.9	WCON 20.4	WCON 35.5	WCON 56.3	WCON 66.5	MNTN 3.0	BEAV 0.6
RC	Reference Category		64L	64L	64L	64L	64L	64L	64L	66	67a
Date	Date	yymmdd	960725	960808	960724	960724	960723	960723	960723	960722	960722
Time	Time	hhmm	1015	1610	1220	1000	1630	1230	930	915	1315
Temp	Water Temperature	°C	21.8	24.5	22.4	21.3	21.7	19.3	18	18.2	17.4
pH	pH (field)	S.U.	7.6	8.4	7.5	7.45	7.45	7.5	7.3	7.15	7.8
DO	Dissolved Oxygen	mg/L	8.04	9.62	8.15	7.22	7.56	8.1	8.27	8.12	8.66
Cond	Conductivity (field)	µ ohms/cm	182	304	230	218	227	155	111	71	304
Alk	Alkalinity (field)	mg/L	44	88	72	66	76	50	34	24	94
Acid	Acidity	mg/L	4	0	6	4	8	6	6	4	2
Lab cond	Specific Conductivity	µ ohms/cm	185	312	234	218	230	156	114	74	309
Lab pH	pH (lab)	mg/L	6.4	8.3	6.6	7.1	7.3	6.4	6.3	6.3	7
Lab Alk	Alkalinity (as CaCO3)	mg/L	42	86	70	64	66	44	28	20	86
D Res	Dissolved Residuals	mg/L	162	262	212	198	156	128	108	80	242
T Res	Total Residuals	mg/L	2	3	2	4	6	2	2	2	10
TN	Total Nitrogen	mg/L	4.22	4.05	2.76	2.93	3.11	1.85	1.41	0.53	6.59
DN	Dissolved Nitrogen	mg/L	4.22	4.05	2.67	2.93	3.11	1.79	1.38	0.47	6.59
DNH3	Dissolved Ammonia	mg/L	0.04	0.02	0.02	0.05	0.03	0.02	0.02	0.02	0.02
TNH3	Total Ammonia	mg/L	0.05	0.09	0.02	0.05	0.03	0.02	0.02	0.04	0.02
DNO2	Dissolved Nitrite	mg/L	0.018	0.006	0.004	0.006	0.01	0.008	0.004	0.004	0.008
TNO2	Total Nitrite	mg/L	0.02	0.006	0.006	0.008	0.012	0.01	0.004	0.004	0.012
DNO3	Dissolved Nitrate	mg/L	3.94	2.89	2.38	2.5	2.72	1.55	1.21	0.37	6.59
TNO3	Total Nitrate	mg/L	3.94	3.69	2.38	2.5	2.72	1.55	1.21	0.42	6.59
TP	Total Phosphorus	mg/L	0.04	0.03	0.13	0.12	0.11	0.06	0.02	0.02	0.02
DP	Dissolved Phosphorus	mg/L	0.018	0.026	0.098	0.097	0.078	0.052	0.015	0.006	0.005
TOC	Total Organic Carbon	mg/L	2.2	2.7	5.5	5.8	4.9	3.5	2.9	3.6	2.3
Hard	Total Hardness (CaCO3)	mg/L	97	109	83	68	80	53	38	23	111
Ca	Total Calcium	mg/L	19	40.2	28.4	25.1	27.1	15.4	10.5	6.51	36.7
Mg	Magnesium	mg/L	6.09	8.75	7.09	7.12	7.43	4.84	3.31	2.28	6.82
Na	Sodium	mg/L	7.57	11.2	7.57	7.21	8.12	6.7	5.54	3.07	12.4
K	Potassium	mg/L	2.04	2.73	3.64	3.67	3.8	2.77	2.24	1.73	2.19
Cl	Chloride	mg/L	14	17	12	11	11	8	6	4	24
SO4	Total Sulfate	mg/L	9	28.1	18.5	17.7	18.5	15.7	10.5	5.8	20.6
Fl	Fluoride	mg/L	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cu	Copper	µg/L	4	4	4.8	4.1	4	4	4	4	4

Parameter Symbol	Parameter Name	Units	SBCD 0.4	SWAT 2.3	WCON 2.9	WCON 20.4	WCON 35.5	WCON 56.3	WCON 66.5	MNTN 3.0	BEAV 0.6
TFe	Total Iron	µg/L	505	248	1,040	627	974	281	154	263	135
DFe	Dissolved Iron	µg/L	36	20	58	55	40	109	61	157	27
Pb	Lead	µg/L	1	1.1	1	1.2	1	1	1	1	1
TMn	Total Manganese	µg/L	81	15	43	48	42	18	10	14	15
DMn	Dissolved Manganese	µg/L	55	12	14	24	17	10	10	10	10
Ni	Nickel	µg/L	4	4	4.6	4.2	5.7	4	4	4	4.4
Zn	Zinc	µg/L	5	6.8	5.7	5.6	5	5	5	5	5
TAl	Total Aluminum	µg/L	84.5	127	367	216	249	102	59.8	97.9	94.9
DAl	Dissolved Aluminum	µg/L	10	20.4	20.1	28.7	13.2	13.9	20.5	60.1	12.8

Parameter Symbol	Parameter Name	Units	ELKN 0.1	LTRT 0.1	MISP 0.5	PENN 50.6	SPRG 0.0	TRDL 0.0	WPIN 0.8	ARMS 0.1	EMAH 17.1
RC	Reference Category		67a	67a	67a	67a	67a	67a	67a	67b	67b
Date	Date	yymmdd	960708	960718	960717	960708	960722	960718	960708	960715	960710
Time	Time	hhmm	1015	1035	1205	1245	1155	1245	1115	1030	1045
Temp	Water Temperature	°C	15.4	15.1	16.4	18.1	16.5	13.9	14.8	22.2	20.4
pH	pH (field)	S.U.	7.6	7.65	7.9	7.85	7.65	7.6	7.3	7.1	7.25
DO	Dissolved Oxygen	mg/L	10.15	9.2	9.16	8.78	8.85	6.78	8.81	8.52	7.93
Cond	Conductivity (field)	µ ohms/cm	288	598	483	316	501	568	201	111	134
Alk	Alkalinity (field)	mg/L	126	232	192	138	188	234	90	24	34
Acid	Acidity	mg/L	6	10	2	4	4	4	8	4	4
Lab cond	Specific Conductivity	µ ohms/cm	300	618	507	333	512	593	210	112	139
Lab pH	pH (lab)	mg/L	8	7.6	7.6	7.8	7.7	7.1	7.5	6.9	6.5
Lab Alk	Alkalinity (as CaCO3)	mg/L	122	228	186	134	186	218	82	20	30
D Res	Dissolved Residuals	mg/L		408	344		394	382		88	177
T Res	Total Residuals	mg/L	2	2	2	3	2	2	16	10	2
TN	Total Nitrogen	mg/L	2.99	6.33	6.86	3.23	6.16	5.45	1.5	1.85	3.11
DN	Dissolved Nitrogen	mg/L	2.64	5.98	6.86	3.05	6.16	5.45	1.44	1.85	3.11
DNH3	Dissolved Ammonia	mg/L	0.02	0.02	0.02	0.06	0.02	0.02	0.02	0.03	0.04
TNH3	Total Ammonia	mg/L	0.03	0.03	0.02	0.12	0.02	0.02	0.02	0.04	0.06
DNO2	Dissolved Nitrite	mg/L	0.004	0.01	0.014	0.01	0.008	0.00	0.004	0.006	0.01
TNO2	Total Nitrite	mg/L	0.018	0.01	0.014	0.01	0.008	0.00	0.004	0.006	0.012
DNO3	Dissolved Nitrate	mg/L	2.68	5.93	6.59	2.37	6.06	5.28	1.25	1.49	2.76
TNO3	Total Nitrate	mg/L	2.75	5.93	6.72	2.41	6.06	5.54	1.3	1.51	2.76
TP	Total Phosphorus	mg/L		0.02	0.05		0.02	0.02		0.02	
DP	Dissolved Phosphorus	mg/L	0.023	0.004	0.047	0.022	0.015	0.01	0.02	0.012	0.018
TOC	Total Organic Carbon	mg/L	1.6	1.2	1.6	2.4	1.4	1.1	1.5	3.5	3
Hard	Total Hardness (CaCO3)	mg/L	115.9	200	201	128.7	213	209	82.1	35.3	48
Ca	Total Calcium	mg/L	53.6	92.1	75.4	57.2	81.8	87.1	37.5	8.58	11.9
Mg	Magnesium	mg/L	5.9	14.8	10.9	7.62	9.93	13.1	3.53	4.06	4.21
Na	Sodium	mg/L	3.15	14.2	10.7	4.77	10.4	14.3	2.52	6.09	4.05
K	Potassium	mg/L	1.51	2.17	2.94	1.98	2.84	2.38	1.08	2.54	2.49
Cl	Chloride	mg/L	6	37	22	8	22	31	4	8	7
SO4	Total Sulfate	mg/L	12.2	26.8	20	16.1	24.2	27.6	10.7	10.5	11.1
Fl	Fluoride	mg/L	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cu	Copper	µg/L	4	4	4	4	4	4	4	4	4

Parameter Symbol	Parameter Name	Units	ELKN 0.1	LTRT 0.1	MISP 0.5	PENN 50.6	SPRG 0.0	TRDL 0.0	WPIN 0.8	ARMS 0.1	EMAH 17.1
TFe	Total Iron	µg/L	152	94	86	460	115	44	118	247	386
DFe	Dissolved Iron	µg/L	30	10	10	33	15	10	26	64	37
Pb	Lead	µg/L	1	1	1	1.9	1	1	1	1	1
TMn	Total Manganese	µg/L	28	10	15	42	16	10	10	21	59
DMn	Dissolved Manganese	µg/L	28	10	11	30	11	10	10	14	59
Ni	Nickel	µg/L	4	4	4	4	4	4	4	4	4
Zn	Zinc	µg/L	13	5	22.9	10.1	5.5	5	12.3	7.3	5
TAl	Total Aluminum	µg/L	84.6	62.8	77.9	209	56.9	23.9	79.1	146	290
DAl	Dissolved Aluminum	µg/L	12.6	10	12.8	15.4	10	10	14.5	17.6	17.9

Parameter Symbol	Parameter Name	Units	LRLN 0.8	LSHM 0.8	LSWT 0.6	MIDL 24.7	MNDA 0.1	NMHT 0.0	NMID 0.7	PAXT 0.5	PAXT 8.4
RC	Reference Category		67b	67b	67b	67b	67b	67b	67b	67b	67b
Date	Date	yymmdd	960708	960709	960718	960709	960722	960719	960709	960716	960715
Time	Time	hhmm	1400	1510	1310	1045	1045	1545	930	1110	1600
Temp	Water Temperature	°C	16.8	23.5	22.4	25.5	16.8	22.5	18.6	21.2	21.8
pH	pH (field)	S.U.	6.55	7.25	7.3	8.8	6.6	8	7.35	7.3	8.21
DO	Dissolved Oxygen	mg/L	9	7.9	8.23	7.36	8.64	8.49	7.98	4.99	8.62
Cond	Conductivity (field)	µ ohms/cm	33	144	260	162	175	190	164	615	291
Alk	Alkalinity (field)	mg/L	8	26	144	64	30	74	54	176	114
Acid	Acidity	mg/L	4	4	12	0	8	2	4	24	1
Lab cond	Specific Conductivity	µ ohms/cm	38	150	259	169	115	195	172	615	318
Lab pH	pH (lab)	mg/L	6.5	6.5	6.8	8.9	6.4	7.8	7.4	7.4	7.9
Lab Alk	Alkalinity (as CaCO3)	mg/L	7.6	34	62	58	28	62	54	166	106
D Res	Dissolved Residuals	mg/L		8	220	92	90	150	118	432	164
T Res	Total Residuals	mg/L	2	2	2	6	2	9	2	2	64
TN	Total Nitrogen	mg/L	0.15	2.93	6.16	1.61	1.23	1.96	1.32	2.73	1.7
DN	Dissolved Nitrogen	mg/L	0.15	2.87	6.16	1.47	1.23	1.96	1.29	2.7	1.44
DNH3	Dissolved Ammonia	mg/L	0.02	0.02	0.06	0.03	0.08	0.02	0.02	0.65	0.02
TNH3	Total Ammonia	mg/L	0.02	0.08	0.06	0.05	0.08	0.03	0.02	0.65	0.02
DNO2	Dissolved Nitrite	mg/L	0.004	0.006	0.048	0.032	0.004	0.006	0.012	0.164	0.012
TNO2	Total Nitrite	mg/L	0.004	0.008	0.05	0.032	0.004	0.008	0.018	0.164	0.012
DNO3	Dissolved Nitrate	mg/L	0.11	2.63	5.63	1.05	1.14	1.51	1.04	1.6	0.94
TNO3	Total Nitrate	mg/L	0.24	2.72	5.63	1.05	1.14	1.51	1.06	1.6	0.94
TP	Total Phosphorus	mg/L			0.07		0.04	0.05		0.05	0.04
DP	Dissolved Phosphorus	mg/L	0.008	0.016	0.032	0.016	0.007	0.038	0.018	0.031	0.01
TOC	Total Organic Carbon	mg/L	1.2	2.1	3.5	5.5	2.1	4.4	2.8	3.8	3.7
Hard	Total Hardness (CaCO3)	mg/L	20.7	44.6	79	58.8	30	73.9	65.5	203.9	100.7
Ca	Total Calcium	mg/L	4.71	17	32.3	23	11.8	26.4	23.2	86.9	39.9
Mg	Magnesium	mg/L	1.25	4.05	7.09	4.49	3.2	3.94	4.74	13.2	7.11
Na	Sodium	mg/L	1.52	6.13	9.91	4.98	4.74	4.27	2.48	32.3	14.6
K	Potassium	mg/L	0.731	2.08	3.53	2.62	1.48	2.95	1.62	4	1.93
Cl	Chloride	mg/L	2	10	15	6	7	7	4	70	22
SO4	Total Sulfate	mg/L	5.1	10	17.6	11.3	9.2	14.3	18.7	39.5	16.8
Fl	Fluoride	mg/L	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cu	Copper	µg/L	4	4	4	4	4	4	4	4	4

Parameter Symbol	Parameter Name	Units	LRLN 0.8	LSHM 0.8	LSWT 0.6	MIDL 24.7	MNDA 0.1	NMHT 0.0	NMID 0.7	PAXT 0.5	PAXT 8.4
TFe	Total Iron	µg/L	70	247	773	277	28	463	196	419	1,120
DFe	Dissolved Iron	µg/L	35	28	35	63	28	46	54	16	45
Pb	Lead	µg/L	1	1.3	1	1	1	1	1	1.4	1.6
TMn	Total Manganese	µg/L	11	18	109	103	15	16	45	255	73
DMn	Dissolved Manganese	µg/L	10	10	109	17	15	10	29	226	22
Ni	Nickel	µg/L	4	4	4	4	4	4	4	4	4
Zn	Zinc	µg/L	19.8	5.6	10	5	5	5	5	17.2	8.2
TAl	Total Aluminum	µg/L	49.5	122	407	41.2	204	380	59.2	54.7	462
DAl	Dissolved Aluminum	µg/L	17.1	10.9	21.1	25.9	16.3	18.3	10.6	11.9	27.8

Parameter Symbol	Parameter Name	Units	POWL 0.1	QUIT 0.3	SWAT 39.0	SWAT 56.0	WMHT 2.2	CLRK 3.8	DEEP 1.2	EPIN 0.1	EPIN 12.7
RC	Reference Category		67b	67b	67b	67b	67b	67cd	67cd	67cd	67cd
Date	Date	yymmdd	960715	960722	960718	960718	960716	960715	960710	960710	960710
Time	Time	hhmm	1200	850	1430	1150	1415	1340	1500	1200	1330
Temp	Water Temperature	°C	21.1	16.8	21.9	19.8	23.2	20.1	21.1	20.5	17.6
pH	pH (field)	S.U.	6.6	7.41	6.7	6.75	8.15	6.65	7.05	7	7
DO	Dissolved Oxygen	mg/L	8.59	8.43	8.69	8.82	8.6	8.86	8.37	8.05	8.75
Cond	Conductivity (field)	µ ohms/cm	64	553	109	270	193	35	84	145	275
Alk	Alkalinity (field)	mg/L	10	192	10	10	70	10	16	14	12
Acid	Acidity	mg/L	4	16	5	6	2	6	6	4	6
Lab cond	Specific Conductivity	µ ohms/cm	68	567	155	209	199	37	88	151	282
Lab pH	pH (lab)	mg/L	6.6	7.7	6.1	6.1	8	6.5	6.3	6.2	6.2
Lab Alk	Alkalinity (as CaCO3)	mg/L	10.4	182	11.2	7.4	62	7.2	13	15	11.4
D Res	Dissolved Residuals	mg/L	52	472	92	178	184	20	116	174	278
T Res	Total Residuals	mg/L	6	2	2	2	5	2	6	2	2
TN	Total Nitrogen	mg/L	1.44	8.45	2.52	0.82	2.35	0.29	1.99	1.55	0.73
DN	Dissolved Nitrogen	mg/L	1.44	8.45	2.52	0.7	2.26	0.29	1.91	1.5	0.73
DNH3	Dissolved Ammonia	mg/L	0.02	0.03	0.02	0.11	0.02	0.02	0.02	0.02	0.06
TNH3	Total Ammonia	mg/L	0.04	0.03	0.03	0.15	0.02	0.02	0.04	0.05	0.06
DNO2	Dissolved Nitrite	mg/L	0.004	0.01	0.014	0.004	0.01	0.004	0.006	0.006	0.004
TNO2	Total Nitrite	mg/L	0.004	0.01	0.014	0.004	0.01	0.004	0.008	0.008	0.004
DNO3	Dissolved Nitrate	mg/L	1.12	7.25	2.32	0.4	1.88	0.18	1.75	1.33	0.57
TNO3	Total Nitrate	mg/L	1.12	7.25	2.32	0.4	1.88	0.18	1.75	1.33	0.57
TP	Total Phosphorus	mg/L	0.02	0.06	0.02	0.02	0.03	0.02			
DP	Dissolved Phosphorus	mg/L	0.007	0.033	0.008	0.002	0.02	0.004	0.008	0.006	0.005
TOC	Total Organic Carbon	mg/L	3.8	1.8	2	2.3	3.4	2	3	3.3	1.5
Hard	Total Hardness (CaCO3)	mg/L	19.9	210	32	65	73.5	10	27	54.9	120.3
Ca	Total Calcium	mg/L	3.99	80.1	7.33	13	25.8	2.87	7.2	13.3	31.6
Mg	Magnesium	mg/L	2.13	14.7	4.07	9.22	5.45	0.87	2.04	5.74	16.1
Na	Sodium	mg/L	3.21	11.4	5.19	9.07	3.94	1.61	2.95	3.42	3.35
K	Potassium	mg/L	1.27	4.85	1.27	1.57	2.78	0.661	1.27	1.45	1.38
Cl	Chloride	mg/L	5	23	6	8	6	3	5	6	4
SO4	Total Sulfate	mg/L	7.2	50.1	22.9	67.8	18.2	5.3	10.6	35.8	110
Fl	Fluoride	mg/L	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cu	Copper	µg/L	4	4.7	4	4	4	4	4.7	4	4

Parameter Symbol	Parameter Name	Units	POWL 0.1	QUIT 0.3	SWAT 39.0	SWAT 56.0	WMHT 2.2	CLRK 3.8	DEEP 1.2	EPIN 0.1	EPIN 12.7
TFe	Total Iron	µg/L	239	400	325	723	328	122	437	618	302
DFe	Dissolved Iron	µg/L	88	15	16	35	32	51	32	51	36
Pb	Lead	µg/L	1	1.7	1	1	1	1	1.1	3.5	1
TMn	Total Manganese	µg/L	21	25	135	671	17	12	28	57	302
DMn	Dissolved Manganese	µg/L	10	10	105	395	10	10	28	47	265
Ni	Nickel	µg/L	4	4	6.6	28.2	4	4	4	4	5.7
Zn	Zinc	µg/L	5	9.8	16.7	57.4	5	5	11.9	8.3	6.7
TAl	Total Aluminum	µg/L	150	127	159	417	189	55.4	82.4	598	147
DAl	Dissolved Aluminum	µg/L	28.9	15.5	13.1	16	15.9	16.1	26.4	25.3	33.4

Parameter Symbol	Parameter Name	Units	LRLS 0.5	STON 0.4	CONO 1.3	CONO 28.8	CONO 51.8	CONO 66.0	EMAH 0.2	MHNY 0.3	MIDL 0.7
RC	Reference Category		67cd	67cd	67L	67L	67L	67L	67L	67L	67L
Date	Date	yymmdd	960716	960715	960718	960718	960717	960717	960718	960710	960709
Time	Time	hhmm	900	1445	1500	905	1400	1015	830	915	1345
Temp	Water Temperature	°C	18.2	19	24	23.7	23.1	21	22.4	19.6	25
pH	pH (field)	S.U.	6.8	6.7	8.05	8.25	8.25	7.85	7.3	7.35	8.3
DO	Dissolved Oxygen	mg/L	8.32	9.14	9.21	7.58	10.51	8.07	7.88	7.88	9.33
Cond	Conductivity (field)	µ ohms/cm	30	27	398	352	345	288	158	755	224
Alk	Alkalinity (field)	mg/L	6	10	148	140	140	116	26	40	54
Acid	Acidity	mg/L	6	6	8	0	0	6	4	4	0
Lab cond	Specific Conductivity	µ ohms/cm	36	29	412	366	355	300	157	800	231
Lab pH	pH (lab)	mg/L	6.2	6.3	7.9	7.8	8	7.2	6.3	6.5	8.3
Lab Alk	Alkalinity (as CaCO3)	mg/L	4.2	3.8	140	134	132	108	22	34	80
D Res	Dissolved Residuals	mg/L	60	22	270	244	248	208	110	894	155
T Res	Total Residuals	mg/L	2	2	10	2	2	2	2	4	5
TN	Total Nitrogen	mg/L	0.38	0.32	4.05	3.7	4.22	4.22	2.58	0.94	1.76
DN	Dissolved Nitrogen	mg/L	0.35	0.29	3.87	3.7	4.22	4.05	2.49	0.94	1.7
DNH3	Dissolved Ammonia	mg/L	0.02	0.05	0.02	0.02	0.02	0.02	0.02	0.03	0.02
TNH3	Total Ammonia	mg/L	0.04	0.05	0.02	0.02	0.03	0.02	0.02	0.03	0.03
DNO2	Dissolved Nitrite	mg/L	0.004	0.004	0.01	0.012	0.014	0.008	0.008	0.006	0.008
TNO2	Total Nitrite	mg/L	0.004	0.004	0.01	0.012	0.014	0.01	0.01	0.006	0.01
DNO3	Dissolved Nitrate	mg/L	0.26	0.09	3.55	3.69	3.95	3.95	2.28	0.83	1.42
TNO3	Total Nitrate	mg/L	0.26	0.09	3.55	3.69	3.95	3.95	2.41	0.83	1.57
TP	Total Phosphorus	mg/L	0.02	0.02	0.02	0.02	0.02	0.02	0.05		
DP	Dissolved Phosphorus	mg/L	0.008	0.004	0.003	0.005	0.005	0.006	0.026	0.005	0.027
TOC	Total Organic Carbon	mg/L	2	5.1	2.8	2.7	2.7	2.5	3	1	3.4
Hard	Total Hardness (CaCO3)	mg/L	10	10	164	147	149	113	59	432.7	90.7
Ca	Total Calcium	mg/L	2.5	2.78	59.3	51	52.6	44.5	19	54.6	33.1
Mg	Magnesium	mg/L	0.92	0.65	9.9	9.09	8.32	6.95	5.38	29.7	7.12
Na	Sodium	mg/L	0.79	0.68	11.7	7.68	6.77	4.77	5.05	9.78	4.28
K	Potassium	mg/L	1.03	0.5	2.52	2.65	2.72	2.54	1.84	1.87	1.92
Cl	Chloride	mg/L	1	1	22	14	13	9	7	8	7
SO4	Total Sulfate	mg/L	6.5	5.8	23.1	17.1	16.3	14.7	28.1	381	19
Fl	Fluoride	mg/L	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cu	Copper	µg/L	4	4	4	4	4	4	4	4	4

Parameter Symbol	Parameter Name	Units	LRLS 0.5	STON 0.4	CONO 1.3	CONO 28.8	CONO 51.8	CONO 66.0	EMAH 0.2	MHNY 0.3	MIDL 0.7
TFe	Total Iron	µg/L	107	180	293	260	200	208	237	973	499
DFe	Dissolved Iron	µg/L	103	69	10	10	38	31	45	15	34
Pb	Lead	µg/L	1	1	1	1	1	1	1	1.2	1
TMn	Total Manganese	µg/L	16	61	21	28	22	17	45	2740	42
DMn	Dissolved Manganese	µg/L	10	32	10	10	17	10	25	2740	10
Ni	Nickel	µg/L	4	4	4	4	4	4	4	43.8	4
Zn	Zinc	µg/L	5.5	21.7	5	5	5	5	5	41.6	5
TAl	Total Aluminum	µg/L	61.3	253	164	145	111	114	143	275	163
DAl	Dissolved Aluminum	µg/L	38.1	161	10	10	10	10	12.4	50.3	20.8

Parameter Symbol	Parameter Name	Units	PENN 5.0	PENN 30.0	SHAM 2.7	SHRM 2.0	SHRM 27.5	SWAT 21.7	WICO 0.3	YLBR 3.4	YLBR 35.7
RC	Reference Category		67L	67L	67L	67L	67L	67L	67L	67L	67L
Date	Date	yymmdd	960709	960708	960709	960716	960716	960724	960718	960722	960722
Time	Time	hhmm	1200	1540	1640	1235	1105	900	950	1405	1040
Temp	Water Temperature	°C	24.6	24.6	23.2	23	22	19.3	21.4	19.7	17.2
pH	pH (field)	S.U.	7.95	8.85	4.25	8.35	7.8	7.41	7.15	7.75	7.6
DO	Dissolved Oxygen	mg/L	7.56	11.01	7.27	9.6	7.24	7.61	8.41	7.94	8.21
Cond	Conductivity (field)	µ ohms/cm	220	204	518	166	214	189	150	280	224
Alk	Alkalinity (field)	mg/L	96	96	0	70	86	56	20	110	102
Acid	Acidity	mg/L	2	0	18	0	4	12	4	6	4
Lab cond	Specific Conductivity	µ ohms/cm	228	214	525	170	219	189	149	286	227
Lab pH	pH (lab)	mg/L	8.1	8.9	4.3	8.1	7.5	6.8	6.3	6.7	6.9
Lab Alk	Alkalinity (as CaCO3)	mg/L	88	86	0	60	82	40	17.2	104	96
D Res	Dissolved Residuals	mg/L	126		394	162	186	178	130	198	160
T Res	Total Residuals	mg/L	2	5	8	6	2	12	2	10	2
TN	Total Nitrogen	mg/L	1.44	1.32	1.73	1.5	2.32	3.17	1.58	2.43	1.85
DN	Dissolved Nitrogen	mg/L	1.29	1.26	1.67	1.44	2.23	3.17	1.52	2.38	1.82
DNH3	Dissolved Ammonia	mg/L	0.02	0.02	1.01	0.02	0.02	0.02	0.02	0.02	0.02
TNH3	Total Ammonia	mg/L	0.05	0.02	1.01	0.04	0.07	0.05	0.02	0.04	0.02
DNO2	Dissolved Nitrite	mg/L	0.008	0.008	0.008	0.008	0.016	0.006	0.004	0.008	0.012
TNO2	Total Nitrite	mg/L	0.012	0.008	0.008	0.012	0.018	0.014	0.004	0.008	0.014
DNO3	Dissolved Nitrate	mg/L	1.18	1.13	0.58	1.18	1.83	3.03	1.28	2.19	1.71
TNO3	Total Nitrate	mg/L	1.18	1.13	0.61	1.18	1.87	3.16	1.28	2.19	1.71
TP	Total Phosphorus	mg/L				0.02	0.02	0.04	0.04	0.04	0.04
DP	Dissolved Phosphorus	mg/L	0.022	0.016	0.004	0.006	0.011	0.013	0.012	0.022	0.018
TOC	Total Organic Carbon	mg/L	2.8	2.2	1.1	3.1	2.3	2.4	2.7	3	1.5
Hard	Total Hardness (CaCO3)	mg/L	89.4	79.3	241.7	64.2	82.2	65	43	101	91
Ca	Total Calcium	mg/L	36.5	35.3	44.1	23.9	32.9	19	13.1	35.1	29.6
Mg	Magnesium	mg/L	5.4	5.01	33	4.31	6.1	5.48	5.36	9.7	10.7
Na	Sodium	mg/L	3.1	2.96	8.94	2.8	2.27	7.49	5.97	7.21	2.32
K	Potassium	mg/L	1.33	1.11	2.79	1.78	1.81	2.22	1.79	2.46	2.14
Cl	Chloride	mg/L	5	5	10	5	5	10	8	12	4
SO4	Total Sulfate	mg/L	13.3	11.7	228	11.4	14.2	20.7	29.6	14.7	8.6
Fl	Fluoride	mg/L	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cu	Copper	µg/L	4	4	5.9	4	4	4	4	4	4

Parameter Symbol	Parameter Name	Units	PENN 5.0	PENN 30.0	SHAM 2.7	SHRM 2.0	SHRM 27.5	SWAT 21.7	WICO 0.3	YLBR 3.4	YLBR 35.7
TFe	Total Iron	µg/L	320	118	3,030	521	648	430	632	666	316
DFe	Dissolved Iron	µg/L	36	22	467	48	30	67	71	40	37
Pb	Lead	µg/L	1	1	2.1	1	1	1	1	1	1
TMn	Total Manganese	µg/L	20	10	2910	26	91	76	83	34	22
DMn	Dissolved Manganese	µg/L	10	10	2480	10	59	48	46	10	10
Ni	Nickel	µg/L	4	4	94.9	4	4	4	4.3	4	4
Zn	Zinc	µg/L	5	5	157	5	5	6.2	8.1	5.6	5
TAl	Total Aluminum	µg/L	116	82.8	854	277	202	164	198	159	105
DAl	Dissolved Aluminum	µg/L	16.9	17.8	466	22.7	15.5	17.3	12.6	19.6	17.5

Parameter Symbol	Parameter Name	Units	SUSQ 10.0	SUSQ 44.5	SUSQ 57.0	SUSQ 77.0	SUSQ 94.0	SUSQ 106.0	SUSQ 122.0
RC	Reference Category								
Date	Date	yymmdd	960814	960813	960813	960813	960812	960812	960812
Time	Time	hhmm	1000	1400	1140	905	1445	1225	930
Temp	Water Temperature	°C	26.3	22.8	22.4	20.6	21.5	25	25.1
pH	pH (field)	S.U.	7.55	8.05	8.15	7.4	7.22	8.05	8.2
DO	Dissolved Oxygen	mg/L	6.54	6.09	6.14	6.93	8.27	6.51	7.44
Cond	Conductivity (field)	µ ohms/cm	248	284	280	256		253	269
Alk	Alkalinity (field)	mg/L	60	80	84	44	40	68	50
Acid	Acidity	mg/L	8	6	4	4	12	6	2
Lab cond	Specific Conductivity	µ ohms/cm	253	284	285	252	267	254	273
Lab pH	pH (lab)	mg/L	7.1	7.8	7.9	7	6.9	7.4	7.5
Lab Alk	Alkalinity (as CaCO3)	mg/L	58	76	76	40	34	64	54
D Res	Dissolved Residuals	mg/L	172	232	212	206	214	212	198
T Res	Total Residuals	mg/L	12	2	8	2	2	2	4
TN	Total Nitrogen	mg/L	2.05	2.02	1.91	0.91	1.14	1.32	1.03
DN	Dissolved Nitrogen	mg/L	1.96	1.7	1.64	0.76	1.03	1.2	0.91
DNH3	Dissolved Ammonia	mg/L	0.02	0.02	0.04	0.02	0.06	0.02	0.04
TNH3	Total Ammonia	mg/L	0.08	0.02	0.04	0.02	0.06	0.02	0.09
DNO2	Dissolved Nitrite	mg/L	0.052	0.006	0.006	0.004	0.004	0.004	0.004
TNO2	Total Nitrite	mg/L	0.082	0.01	0.01	0.004	0.004	0.004	0.008
DNO3	Dissolved Nitrate	mg/L	1.36	1.3	1.31	0.55	0.75	0.92	0.64
TNO3	Total Nitrate	mg/L	1.37	1.38	1.31	0.55	0.79	0.95	0.65
TP	Total Phosphorus	mg/L	0.08	0.06	0.06	0.03	0.02	0.02	0.02
DP	Dissolved Phosphorus	mg/L	0.024	0.012	0.011	0.007	0.01	0.016	0.005
TOC	Total Organic Carbon	mg/L	3.4	4.1	4	2.6	2.3	2.3	2.6
Hard	Total Hardness (CaCO3)	mg/L	74	81	60	65	98	83	77
Ca	Total Calcium	mg/L	29.3	31	36.7	29.1	30.6	37	31.7
Mg	Magnesium	mg/L	8.51	7.93	9.07	9.69	11.3	8.43	8.17
Na	Sodium	mg/L	11.6	12.7	13.2	9.7	8.59	4.92	12
K	Potassium	mg/L	2.6	3.15	3.05	1.78	1.89	1.77	1.98
Cl	Chloride	mg/L	16	20	20	15	12	9	20
SO4	Total Sulfate	mg/L	32.1	28.9	29.1	54.4	73.7	42	44.9
Fl	Fluoride	mg/L	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cu	Copper	µg/L	4	4	4	4	4	4	4

Parameter Symbol	Parameter Name	Units	SUSQ 10.0	SUSQ 44.5	SUSQ 57.0	SUSQ 77.0	SUSQ 94.0	SUSQ 106.0	SUSQ 122.0
TFe	Total Iron	µg/L	1,230	686	949	381	355	229	251
DFe	Dissolved Iron	µg/L	24	36	35	43	27	11	12
Pb	Lead	µg/L	1.2	1	1.6	1	1	1	1
TMn	Total Manganese	µg/L	186	103	131	182	122	81	75
DMn	Dissolved Manganese	µg/L	12	28	26	80	68	31	18
Ni	Nickel	µg/L	4	4	4	4	4	4	4
Zn	Zinc	µg/L	8.8	5	6.5	10.5	8.4	5	12
TAl	Total Aluminum	µg/L	369	167	230	111	60.4	87.2	123
DAl	Dissolved Aluminum	µg/L	22.9	23.3	23.5	20.9	16.4	19.1	85.7